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Development of a Dynamic Traffic Assignment Model for Northern Nevada

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Nevada Department of Transportation

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DEVELOPMENT OF A DYNAMIC TRAFFIC ASSIGNMENT MODEL FOR NORTHERN NEVADA

June 2014

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Prepared by

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FINAL REPORT

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EXECUTIVE SUMMARY

The research project *Development of a Dynamic Traffic Assignment Model for Northern Nevada* was conducted over a ten-month period from August 2013 to June 2014. The project covered the development of a Dynamic Traffic Assignment (DTA) model for the Reno-Sparks Urbanized Area roadway network in Northern Nevada.

A literature review was conducted regarding DTA model development and applications. The details of the DTA model development for the Reno-Sparks network were documented along with necessary model calibration. We adopted NeXTA/DTALite for developing the DTA model. This software package was selected since it has a rigorous traffic queuing model and its built-in parallel computing capability speeds up the analysis process by using multi-core CPU hardware.

The Regional Transportation Commission of Washoe County (RTC) maintains the regional TransCAD travel demand model. RTC provided the up-to-date TransCAD model, and the DTA development was primarily based on the network and Origin Destination (OD) demand data from TransCAD. Model calibration was done by comparing the DTA generated link volumes and those obtained from NDOT's TRINA database, which includes the AADTs on major roadway links collected from permanent and temporary traffic count stations.

The DTA model development included the following major steps:

- Import the network and demand data from TransCAD into NeXTA;
- Perform a dynamic traffic assignment in DTALite to achieve an equilibrium to produce an initial DTA model;
- Prepare field data and run Origin Destination Matrix Estimation (ODME) for network calibration.

Major findings from this research are summarized below:

Capabilities and benefits of DTA

- DTA is mesoscopic in nature, providing a connection between regional travel demand forecasting and micro-simulation models. It is one step further from the planning level travel forecasting towards the operating details of micro-simulation, i.e., DTA analyzes large networks as a travel demand forecasting tool and provides time-varying traffic network performance (e.g., queue formation, bottleneck identification) but not as much detailed as micro-simulation models.
- Comparing with micro-simulation models which normally represent known traffic flow patterns, DTA can both represent current traffic performance and evaluate near-term traffic flow impacts from network changes. It is particularly useful to model a regional level network to forecast traffic flow pattern changes and operational impacts due to incidents such as work zone, special events, and accidents.

Requirements for DTA Development and Applications

- Geometric data, traffic control data, traffic demand, OD demand data and transit demand are basic requirements for network development.
- For model calibration, the fidelity of a DTA model depends on more than link volumes. Typical types of data for calibration strategies can include: travel times, travel speeds, queue information, and transit operations.
- Transportation modeling techniques and various levels of efforts are needed depending on the model complexity and data availability.

Limitations of DTA Applications

- For long-term planning, DTA may not be able to produce a well-calibrated model because of the lack of future travel demand data and corresponding field data. Instead, travel forecasting models such as TransCAD is a better fit for bottlenecks estimation studies. While DTA can only identify active bottlenecks, travel demand forecasting models can predict all potential bottleneck locations, which is necessary for long-term planning purposes.
- The level of precision from DTA models largely depends on data availability. DTA requires a significantly larger amount of data which may not be readily available in most cases. Decision makers need to assess the desired level of precision and the available resources and choose if DTA or conventional travel demand models should be used.
- For a more localized network or subarea where detailed traffic operational analysis is desired (e.g., transit service and pedestrian facility, turn pockets design, signal control, freeway reconstruction), micro-simulation is a better tool.

Future Research Focuses

The DTA calibration conducted in this project is considered limited due to data availability and time constraints. Future efforts should be directed to the following aspects:

- In the current DTA model, detailed signal timing and turn pockets are not coded. It would be interesting to test how sensitive the DTA results are with regard to adding such detailed information.
- Current model calibration was based on AADT link counts. We did not distribute AADT counts over time of day, nor did we obtain time-dependent (e.g. hourly) link volumes. Further calibration can be performed if hourly link volumes, peak hour link volumes, or distribution of link volume over time is given.
- Further calibration should utilize link speed data, which is easily accessible from NDOT maintained Intelligent Transportation Systems (ITS) devices. Accurate link speed data

can be input into the sensor_count.csv file. NeXTA/DTALite can utilize them to conduct model calibration.

- Some case studies should be conducted to demonstrate the applicability of DTA models. Very limited literature was found to document such case studies. In the case of traffic incidents, a comparison between DTA generated results and the actual field performance will give transportation agencies some confidence level of the validity of DTA modeling.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

1.1 Project Background

An increased number of transportation agencies are expressing interest in the application of Dynamic Traffic Assignment (DTA) models due to the many advantages these models possess compared to macroscopic travel demand models and microscopic traffic simulation models. NDOT recently completed a project that involved development of a DTA model using DynusT for the Las Vegas urban areas. It is NDOT's desire that a similar model will be developed for the Reno-Sparks Urbanized Area in Northern Nevada. The application of Dynamic Traffic Assignment (DTA) models requires better knowledge of the update-to-date information about the roadway network and intricate calibration of DTA performance with micro-simulation at the study site. The calibration and validation process is critical for building a consistent and reliable DTA model. However, few guidance or standards exist for the calibration of DTA performance at a region-wide network level. In practice, DTA calibration is usually conducted by qualitatively assessing the results and to some degree quantitatively comparing against the macroscopic observations. The difficulties in validating detailed performance measures such as route choice and experienced travel time arouse some doubts from the public and decision makers. Therefore, the actual DTA model performance needs to be carefully calibrated with some refined tools.

1.2 Research Objective

The objective of this research is to build and calibrate a DTA model for Northern Nevada (Reno-Sparks Area) based on the network profile and travel demand information updated to date. The critical procedures include development of consistent and readily adaptable DTA model, model validation, and calibration based on observed field data. The DTA software package used to develop the DTA model in this project is NeXTA/DTALite.

2 LITERATURE REVIEW

Accurate prediction of the changes in vehicular flow pattern over the entire roadway network serves unarguably as an important component in transportation planning and management. While a certain traffic pattern can be obtained through the static traffic assignment in the last step of the conventional four-step transportation planning process (Beckman et al. 1956), it is limited in its ability to capture the detailed behavior of traffic. The traditional static techniques fail to incorporate the knowledge of non-stationary conditions on roadway segment such as queue spillover, oversaturation and dynamic routing.

Microscopic simulation models are typically employed to represent finer resolution of traffic dynamics by simulating the movement of individual vehicles (Sbayti and Roden, 2010). They are usually applied to analyze various geometric design configurations and evaluate the impact of new traffic signal systems in a local area. However, microscopic simulations are limited to corridor level evaluations, lacking the regional level scope of travel behavior patterns.

Dynamic Traffic Assignment (DTA) models, on the other hand, provide more realistic traffic patterns by taking into considerations the time-varying traffic conditions such as queue formation, traffic signal timing, and route choice decisions. DTA overcomes the unrealistic assumptions of static models and incorporates the travel behavior information at regional level (Peeta and Ziliaskopoulos, 2001). Since DTA models are able to represent the interactions between travel choices and time-varying network conditions in a coherent manner, the results can serve as many meaningful measures to analyze travel time reliability, congestion and sensitivity analysis for region-wide planning and operational purposes.

Given the time-dependent characteristics of demand and traffic conditions over the network as input, DTA models seek time-space vehicular trajectories to achieve certain objectives. The typical objectives are to minimize total experienced travel costs or to achieve the converged traffic equilibrium patterns. In practice, this could be done by simulation-based DTA algorithms, which iteratively determine time-varying route and link volumes and travel times in terms of so-called dynamic user equilibrium (DTA Primer, 2011). It typically requires extensive computation to complete the following three major procedures: path set update, routing choice algorithm, and traffic flow simulation. Although these simulation-based algorithms assign vehicles along paths according to the updated road segment information using a certain traffic flow model, their approaches are different in many ways from each other. The two major simulation-based DTA software suites that are widely used are briefly reviewed as follows.

DynusT (Dynamic Urban Systems for Transportation) is a suite of open-source DTA software used for operational planning analysis (DynusT, 2011). It employs an iterative framework to perform traffic assignment for evaluating long-term impact of changed network conditions. DynusT uses the anisotropic mesoscopic simulation model, a modified version of Greenshield's model, to simulate the traffic flow propagation (Chiu et al. 2010). In this model, the vehicle speed depends upon the average density in a certain downstream area. Five user classes (unresponsive, system optimal, user equilibrium, en-route information, and pre-trip information) are defined in DynusT and are provided as proportion in the traffic stream in order to provide capabilities for various purposes in practice.

DTALite (Light-weight Dynamic Traffic Assignment Engine) is another widely adopted mesoscopic simulation-assignment software. It features a minimum requirement of data input from static traffic assignment data and some time-dependent OD demand estimates (DTALite website, 2013). Compared to other similar software packages, DTALite uses a built-in parallel computing technique to dramatically shorten the simulation and routing processes with widely available multi-core CPU hardware. Furthermore, its underlying traffic flow model is more theoretically rigorous. It embeds a simplified spatial queuing model which uses Newell's cumulative-count based traffic flow theory to consider queue propagation and spillback (Newell, 1993). This model is theoretically equivalent to widely used cell transmission model (Daganzo, 1994 and 1995). The above features equip DTALite with the capability of both traffic realism and computational efficiency.

Both DynusT and DTALite share the same user-friendly front-end graphical user interface (GUI), NeXTA (Network EXplorer for Traffic Analysis). Our research team has full-scale experience with the NeXTA utility. In fact, NeXTA is very convenient and flexible in practice. For data input, it allows users to create new networks, modify existing datasets, specify analysis scenarios and set simulation parameters. For output data, it allows to perform post-processing analysis and conduct analysis of the results from the simulation-based assignment (NeXTA website, 2013). Compared to other similar mesoscopic simulation software, these features in NeXTA make DynusT and DTALite more convenient in use in practice.

The above mentioned DTA software and related DTA models, due to their flexibility and capability for transportation operational and planning purposes, are anticipated to be widely used in a variety of FHWA initiatives such as Connected Vehicles, integrated corridor management, and active transportation and demand management. There is no question that the application of DTA models to the region-wide network in Nevada is also beneficial in many ways to support the FHWA initiatives. In this project, we will use NeXTA/DTALite software package as the development tool to build a regional DTA model for Northern Nevada network and perform limited model calibration based on field data. It is evident that this project, which demonstrates the procedure of building and partially calibrating a regional DTA model, will directly contribute to advancing NDOT's traffic operational and planning programs and supporting the FHWA initiatives.

3 INITIAL DTA MODEL FOR NORTHERN NEVADA

3.1 GIS Setting and Traffic Demand

A dynamic traffic assignment tool needs time-dependent Origin-Destination (O-D) demand data and associated network with Traffic Analysis Zone (TAZ) profiles. Then the DTA tool assigns vehicles to different paths based upon varied link travel time across a section of time. Such assignment is according to time-dependent shortest path algorithm or other assignment rules, constrained to a set of speed-density relationship and capacity of links and to the traffic signal timing (if any) at each node.

The typical input data for DTA tools includes network profile and demand data. The network data including link attributes and topology information are usually coded in GIS format with different coordinate systems, while the demand data are usually obtained from traffic demand model and are coded in a range of formats, such as matrices and columns.

In order to implement the DTA model, we used the O-D demand data of multiple vehicle types in November 2010, and the corresponding network profile of Reno-Sparks regional area.

3.1.1 Network Profile

Regional Transportation Committee (RTC) of Washoe County maintains regional travel demand model in Caliper TransCAD®®. This network was converted to a set of shape files before being imported into NeXTA. This was accomplished using export tool in TransCAD®. The full network is imported into NeXTA to retain accuracy. A screen shot of the network with TAZs in NeXTA is presented in Figure 1.

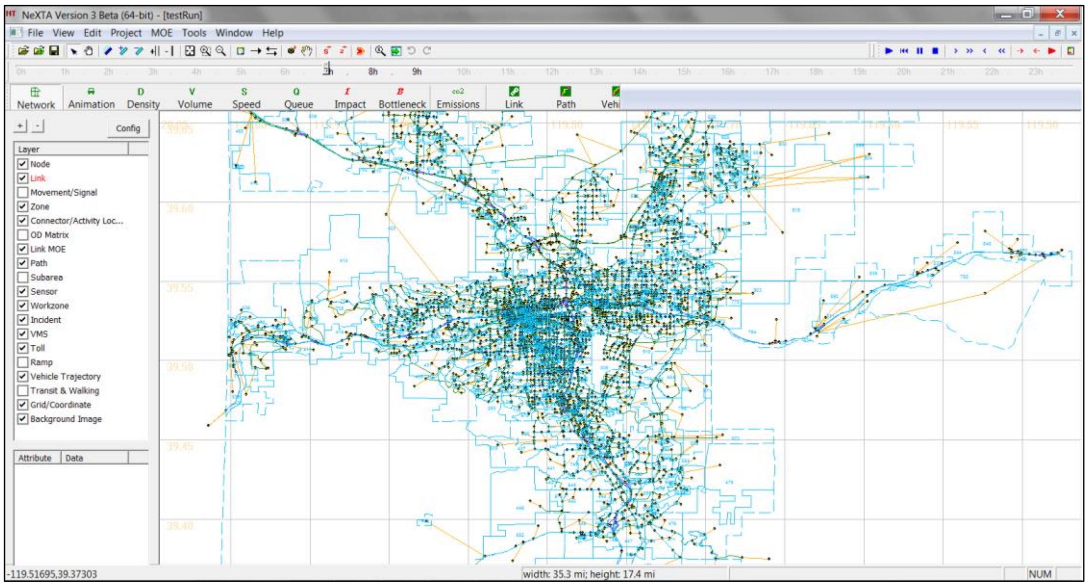


Figure 1. Computer Screen of Reno-Sparks Network with TAZs in NeXTA

3.1.2 Travel Demand Data

The time-dependent demand data we imported into DTALite are in the format of OD matrix, which covers a 24-hour trip demand for different vehicle types and with different peak and off-peak periods. Demand types considered in the demand files contain Single Occupancy Vehicle (SOV) passenger car, 2-person High Occupancy Vehicle (HOV2), HOV3, single-unit truck, multi-unit truck and local bus. The demand data covers 24 hours of an entire day. A 24-hour day is then divided into four time periods, i.e. nt, am, md and pm. A detailed description of time periods is shown in Table 1.

Table 1 Time Periods of Demand Data

Name	Meaning	Time of day
am	AM peak period	6:00am – 9:00am
md	Midday period	9:00am – 4:00pm
pm	PM peak period	4:00pm – 7:00pm
nt	Night time	7:00pm – 6:00am

3.2 Build Traffic Assignment through NeXTA/DTALite

DTALite employs an agent-based, simulation-based mesoscopic dynamic traffic assignment framework by using a link-based simulation to incorporate the time-dependent O-D matrices. Since the link-based simulation is subject to the capacity limitation, such framework is able to capture the dynamic traffic flow across a certain time period. When simulating link traffic flow, the DTALite provides a flexible choice in a set of traffic flow models to meet various practical requirements.

3.3 Initial Results for North Nevada Regional DTA Simulation

An overview of the Reno-Sparks network data is provided in Table 2. Table 3 presents the changes of some Measures of Effectiveness (MOEs) according to different time in minutes. For illustration purposes, we present the changes in speed, volume and queues in figures. Figure 2 (a) to (c) illustrate the changes of average speed at 8:00am, 4:00pm and 5:00pm, respectively. We can observe that the speed at some section of highway turns to increase at the end of analysis period. A similar observation can be also obtained from Figure 3 for the volume, and from Figure 4 for the density. The illustration of queues with deep colors in Figure 5 shows the traffic bottleneck around the network.

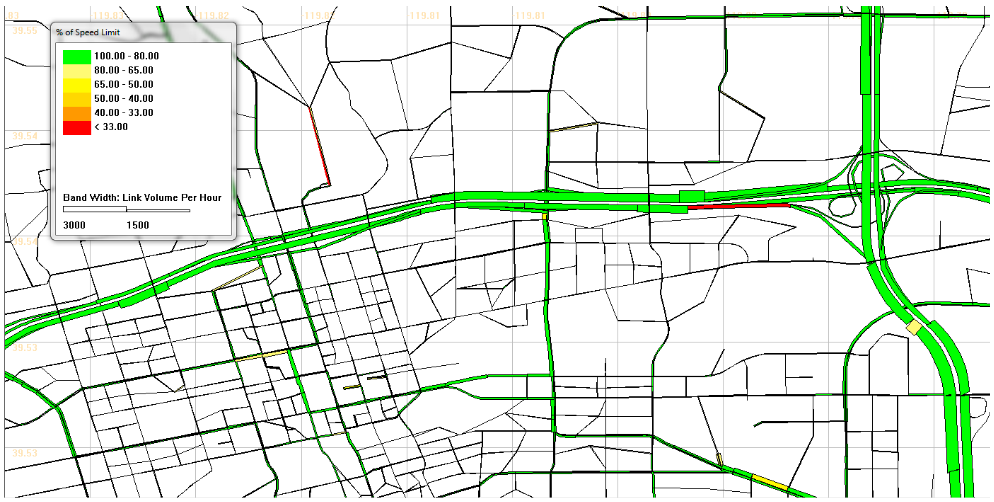
Table 2. Network Data Overview

Name	Value
Nodes	4533
Links	11919
Zones	904
Activity Locations	904
Link Types	10

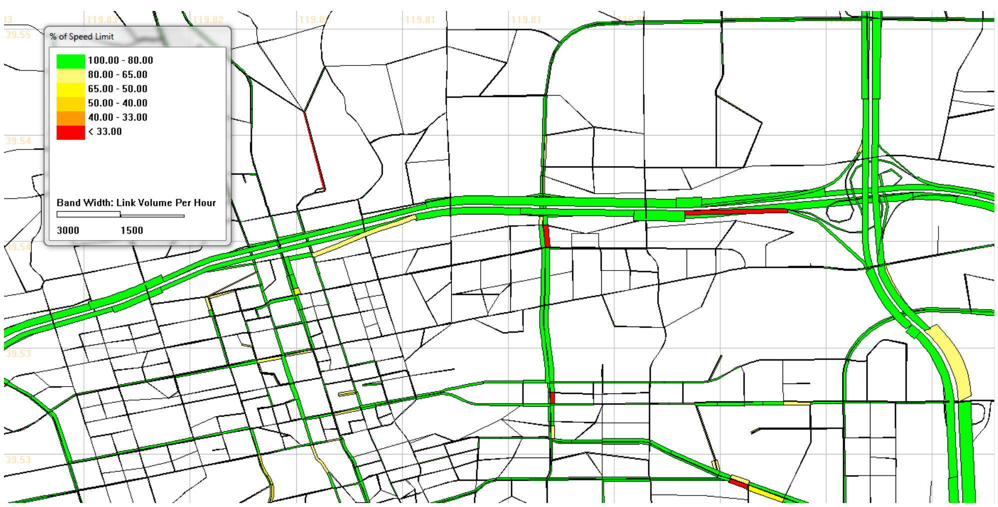
Table 3. A Sample of Network MOEs across the Simulation Time

Time in min	Cumulative in Flow Count	Cumulative Out Flow Count	Flow per Minute	Average Trip Time in Minute
7:06	198087	12114	23500	10.6393
7:07	199308	12090	23940	10.4276
7:08	200536	12007	22900	10.1679
7:09	201740	12049	24920	10.0951
7:10	202958	12030	23980	10.5174
7:11	204111	11976	21980	9.94238

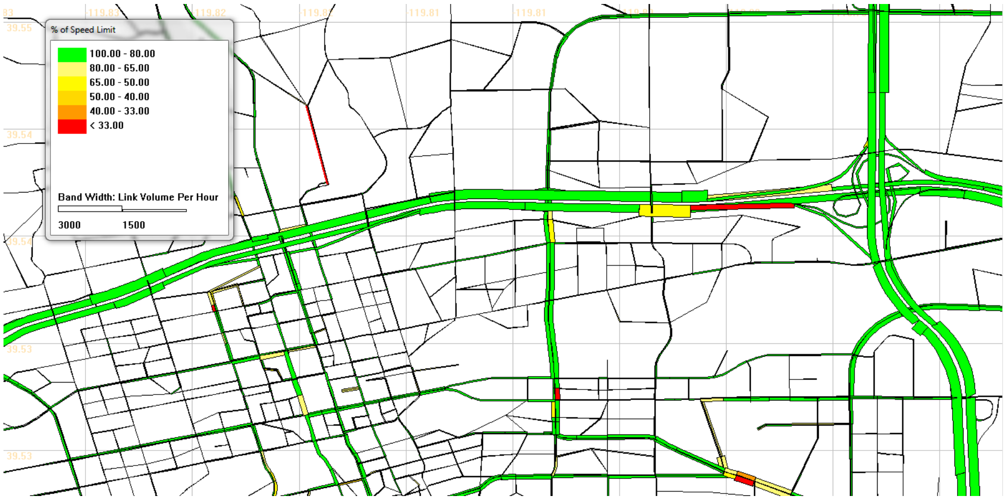
Time in min	Cumulative in Flow Count	Cumulative Out Flow Count	Flow per Minute	Average Trip Time in Minute
7:12	205348	11995	25120	10.9174
7:13	206519	11978	23080	10.2278
7:14	207693	11986	23640	9.98826
7:15	208851	12149	26420	10.9645



(a) 8:00am



(b) 4:00pm

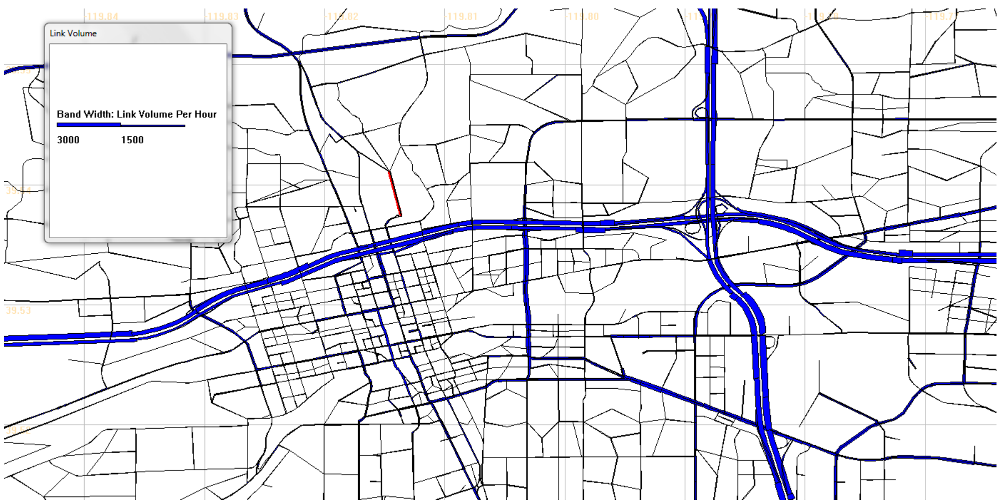


(c) 5:00pm

Figure 2. Changes in Average Speed on Different Road Sections over Time

(a) 6:00am

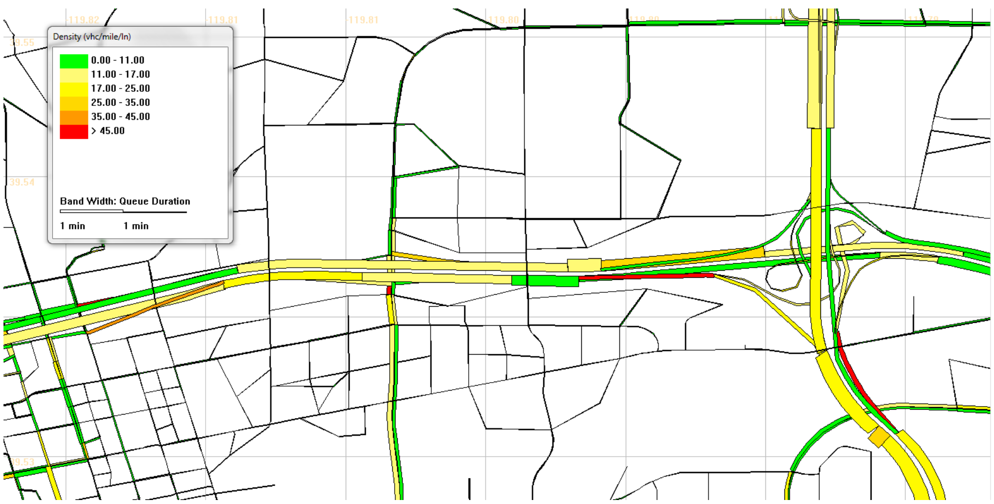
(b) 8:00am



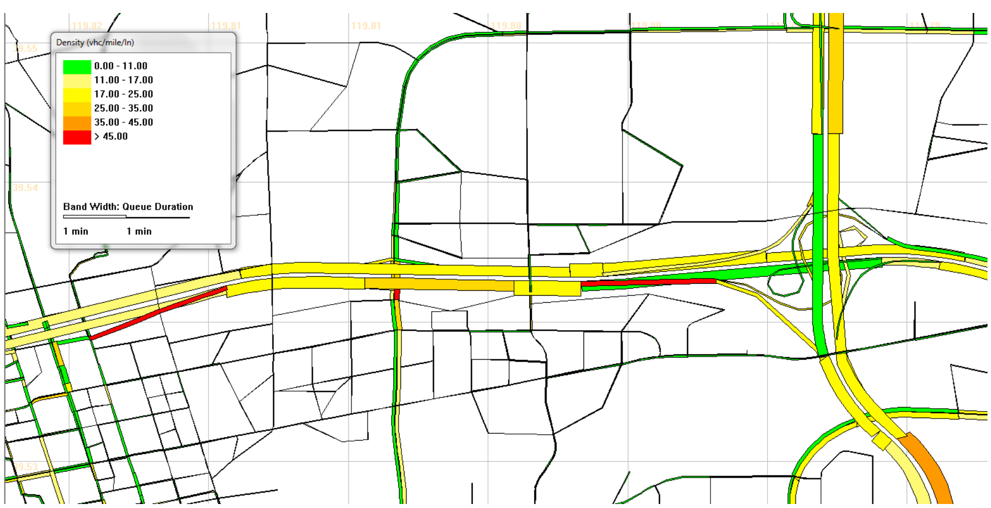
(c) 5:00pm

Figure 3. Changes in Volume on Different Road Sections over Time

(a) 6:00am



(b) 7:00am



(c) 5:00pm

Figure 4. Changes in Density on Different Road Sections over Time

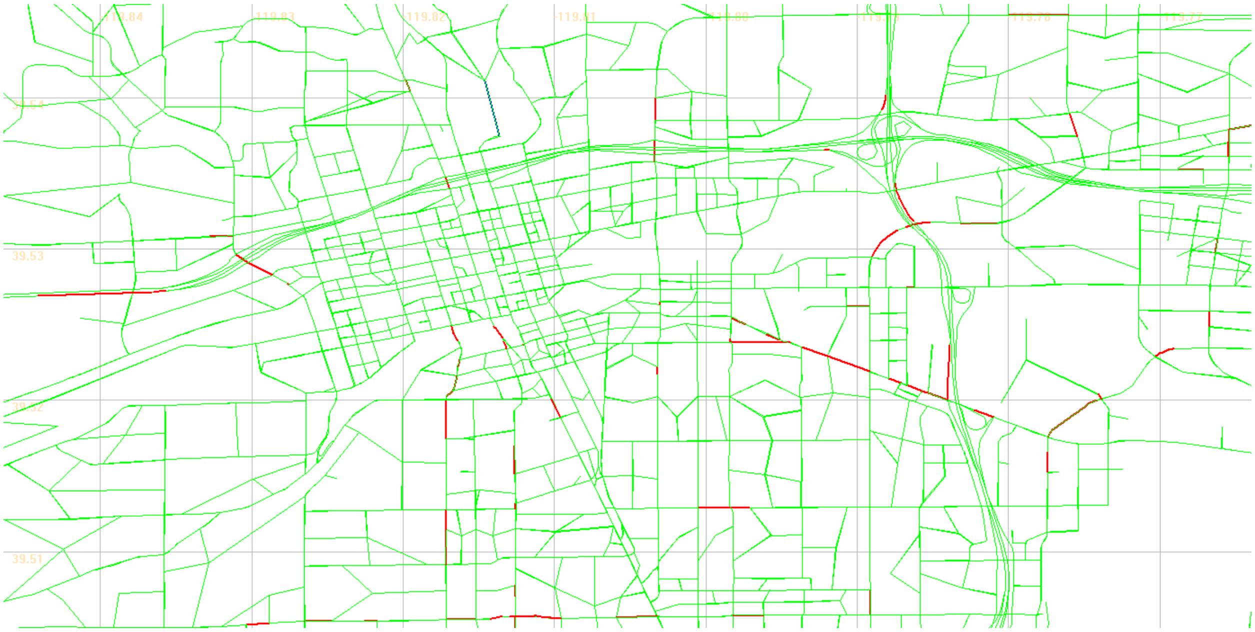


Figure 5. Illustration of Queues at 8:30am (Red Color Denotes a Long Queue)

4 PROCEDURE FOR MODELING WITH NeXTA/DTALite

The overview of procedures we conducted in this project is the following.

Step 1: Export network and demand files from TransCAD® regional travel demand model;

Step 2: Use NeXTA's import network tool to import GIS network;

Step 3: Import demand data into NeXTA from regional travel demand model;

Step 4: Run assignment with DTALite to equilibrium;

Step 5: Change configurations in input_scenarios_settings.csv file;

Step 6: Prepare field data for ODME (Origin Destination Matrix Estimation);

Step 7: Run ODME using field data for calibration of the whole network;

Step 1 is the basic process of data preparation before running dynamic traffic assignment. Steps 2 to 4 conduct network and demand data conversion from regional travel demand model to a DTA-compatible network, and after the simulation runs it can yield an initial DTA model according to the network profile and travel demand data. Steps 5 to 7 are the procedure to calibrate the DTA model using field data (in this case, link volume data).

4.1 Export Network and Demand Files from TransCAD®

The first step in the network conversion process is to create a set of shape files describing the network to be imported into NeXTA. This is normally accomplished using export functions in the software used to prepare the selected network, and can be divided into three internal steps: 1) Load the network of regional demand model in originating software; 2) Export network as shape files; and 3) Export demand matrices/tables.

4.1.1 Load the Network in TransCAD®

The Reno-Sparks network was coded in TransCAD® and must be exported as a set of shape files. First, the network is loaded in TransCAD® as shown in Figure 6.

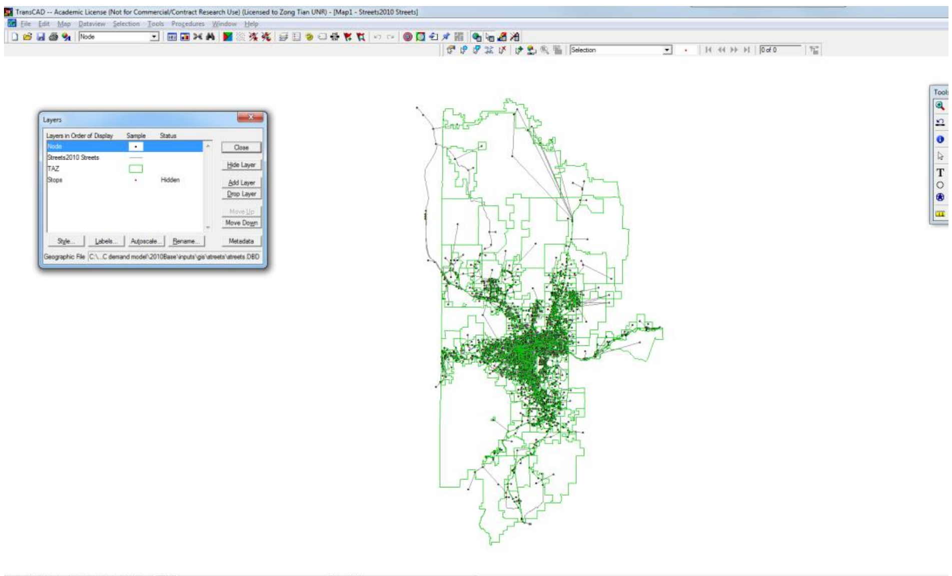
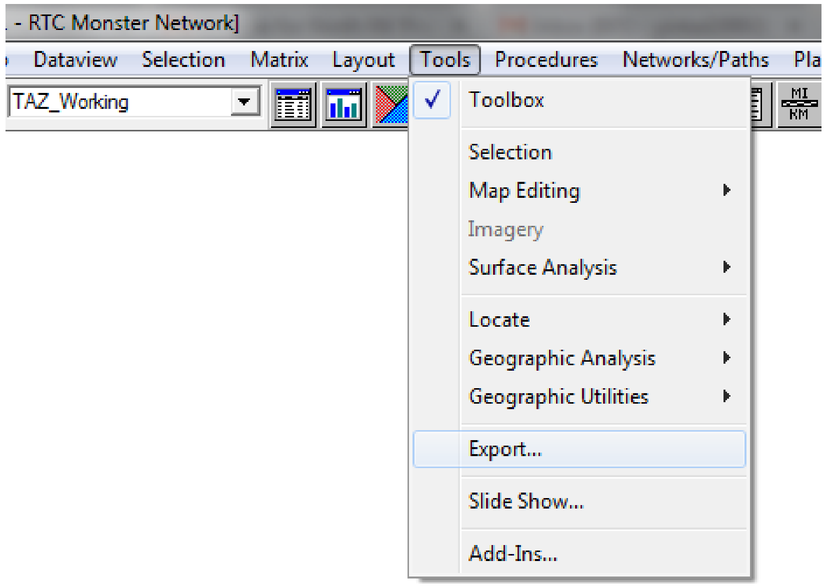


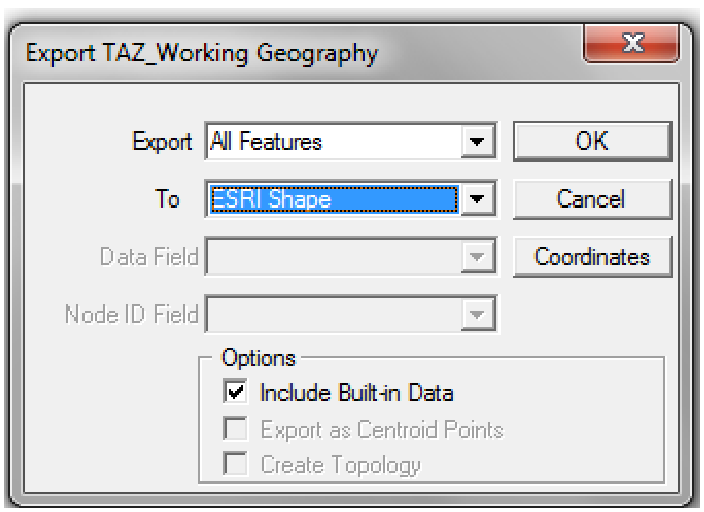
Figure 6. Reno-Sparks Regional Travel Demand Model Loaded in TransCAD®

4.1.2 Export Network as Shape Files from TransCAD®

By using the export tool in TransCAD® to export the network GIS shape files, the network is split into multiple component layers and saved as separate shape files. One should select the node, link and TAZ zone layers to ensure that the conversion process can successfully create a new network in NeXTA. An example process of exporting a layer to a shape file is shown in Figure 7.



(a) Choose Export Tool in Menu

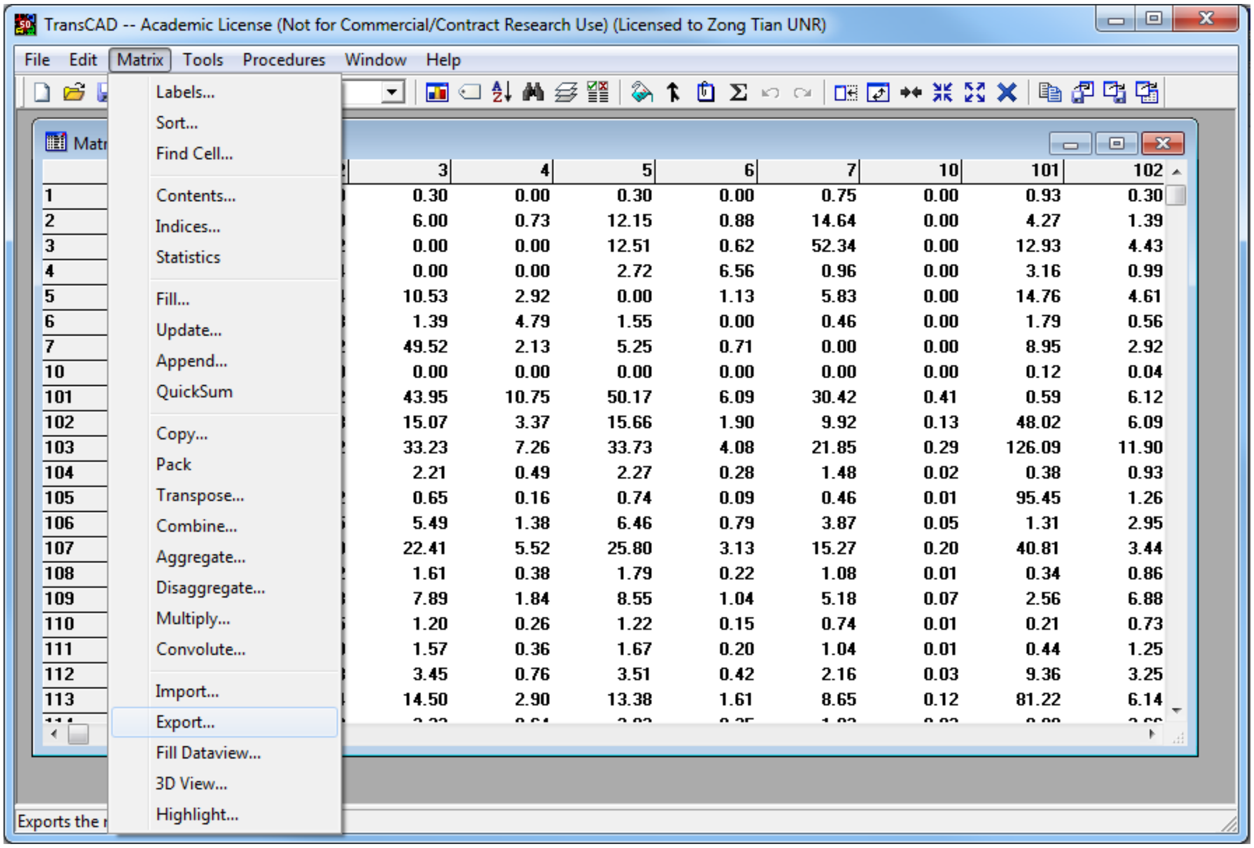


(b) Choose Export Option

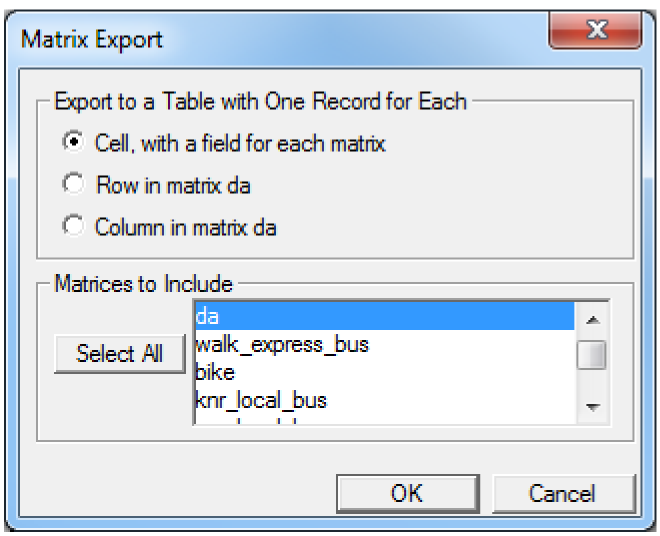
Figure 7. Exporting Network Data as Shape Files

4.1.3 Export Demand Tables/Matrices from TransCAD®

The demand matrices in TransCAD® are stored as binary files. In order for NeXTA/DTALite to read demand data, one can export the demand matrix files from TransCAD® into the "Export to a table with one record for each cell, with a field for each matrix" option when preparing tables for export to NeXTA, as shown in Figure 8. Exporting the demand matrices for Reno-Sparks travel demand model produces 24 demand tables describing the number of trips between zones for different demand types and different time periods.



(a) Exporting Matrix in TransCAD®



(b) Matrix Export Option in TransCAD®

Figure 8. Export Demand Matrices from TransCAD®

The exported shape files and the matrices are placed in a destination folder. The folder should contain the following files:

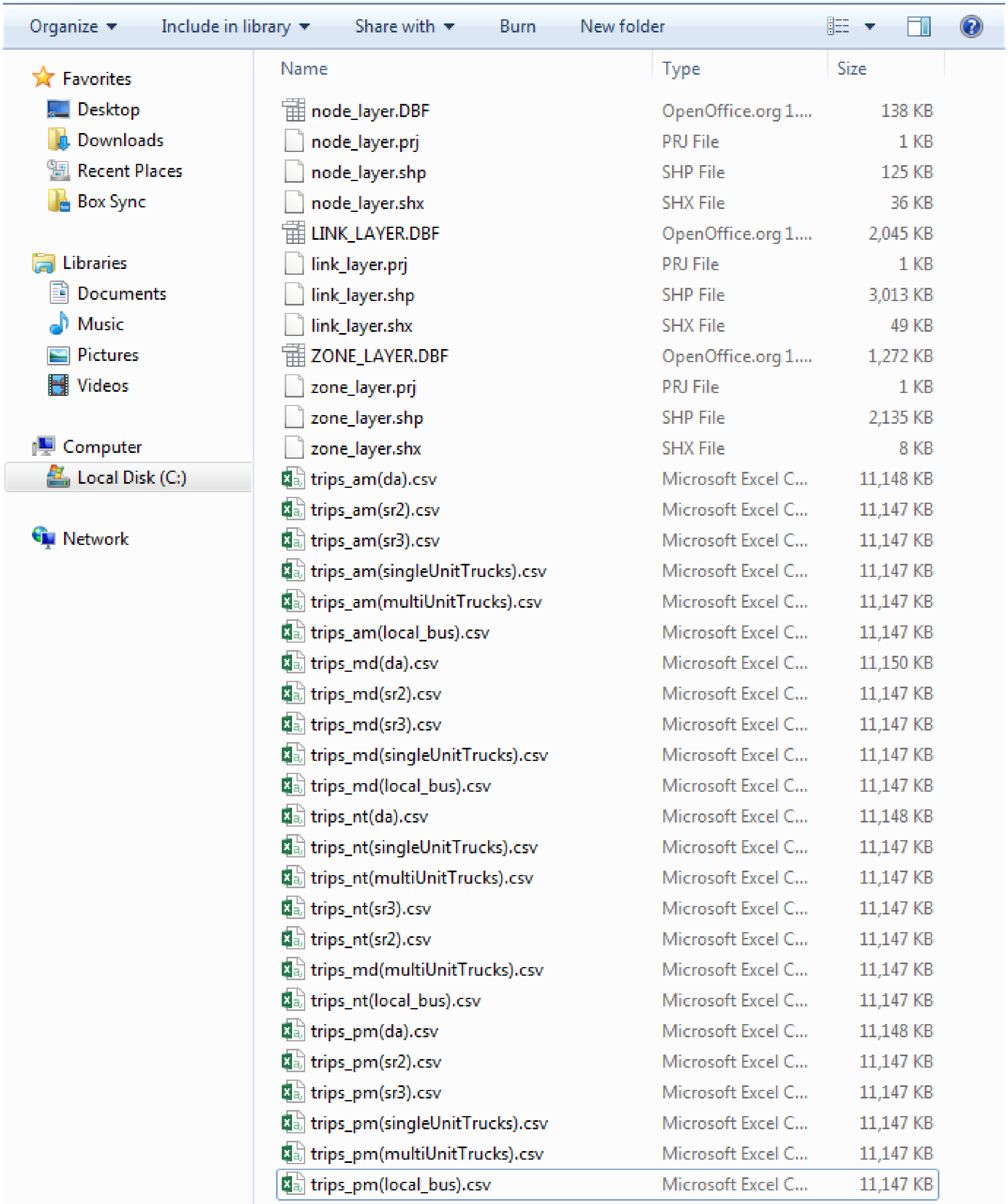


Figure 9. Exported Files in Destination Folder

4.2 Use NeXTA's Import Network Tool to Import GIS Network Shape Files.

4.2.1 Prepare Configuration Files for Conversion

The first step in converting the network is to create several configuration CSV files in the folder containing the exported shape files. The required configuration files include (1) input_node_control_type.csv, (2) input_link_type.csv, (3) input_demand_meta_data.csv (and related demand files), and (4) import_GIS_settings.csv. To ensure that NeXTA imports a correct network profile, in this step one needs to update the configurations of link types, node control types and GIS settings.

Link types to be imported into NeXTA should be consistent with the types used in original TransCAD® network. In the network a different list of link types is used than the default values given in the NeXTA configuration files. For that reason, input_link_type.csv file needs to be updated to reflect the current types.

The updated link type table should look like as follows:

Table 4. Updated Configurations for Link Type

link_type	link_type_name	type_code	default_lane_capacity	default_speed_limit
0	Private roads	t	650	25
1	Interstate freeway	f	1800	65
2	principal arterial	a	1800	65
3	Other principal arterial	a	1000	45
4	Minor arterial	a	850	35
5	Major collectors	a	650	35
6	Minor collectors	a	650	25
7	Local streets	a	650	25
8	Ramps	r	1600	55
9	Centroid connectors	c	99999	15

The input_node_control_type.csv file should also be updated with the current control type, especially for signalized intersections. Codes for control types must be consistent with the settings in network profile exported from TransCAD®. The updated node control type table should look like this:

Table 5. Configurations for input_node_control_type.csv

control_ type_name	unknown _control	no_ control	yield_ sign	2way_ stop_sign	4way_ stop_sign	pretimed _signal	actuated _signal	roundabout
control_type	0	1	2	3	4	5	6	100

The import_GIS_settings.csv file is to identify and connect the fields in the input shape file (DBF files) to the AMS data hub schema data format, allowing NeXTA to read the network geometry from shape files and create an AMS data hub compatible transportation network project (.tnp) file (which is readable by both DTALite and NeXTA). Figure 10 shows a screenshot of the beginning section of updated GIS setting table.

section	key	value	required_or_optional
file_name	node	node_layer.shp	desired
file_name	link	link_layer.shp	required
file_name	zone	zone_layer.shp	desired
file_name	centroid		
file_name	connector		
configuration	with_decimal_long_lat	yes	
configuration	length_unit	mile	
configuration	number_of_lanes_oneway_vs_twoway	oneway	
configuration	lane_capacity_vs_link_capacity	lane	
configuration	multiplier_for_obtaining_hourly_capacity	1	
configuration	direction_0_as_oneway_vs_twoway	twoway	
configuration	default_link_direction	twoway	
configuration	node_number_threshold_as_centroid	0	

Figure 10. Screenshot. Beginning Section of input_GIS_settings.csv

4.2.2 Use NeXTA's Import Network Tool to Convert the Network

Using NeXTA's "Import GIS Planning Data Set" tool under Menu—File—Import—GIS Planning Data Set, the network exported from TransCAD® can now be imported into NeXTA. The conversion process is shown in Figure 11.

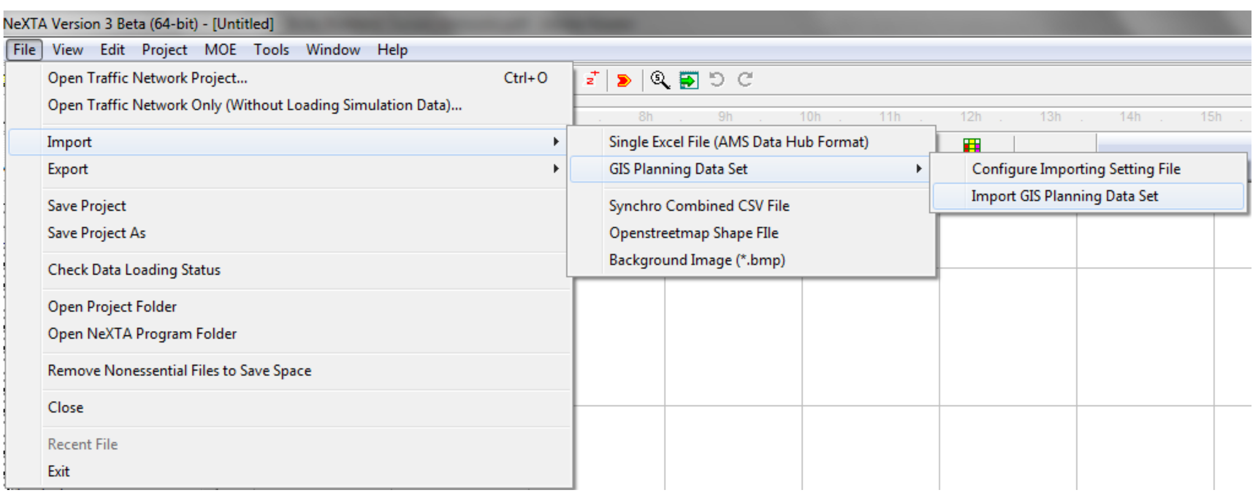


Figure 11. Import Planning Shape Files

After the successful conversion process, NeXTA displays a "File Loading Status" window as shown in Figure 12.

The final imported network is shown in Figure 13, which has 4,533 nodes, 11,919 links, and 904 zones.

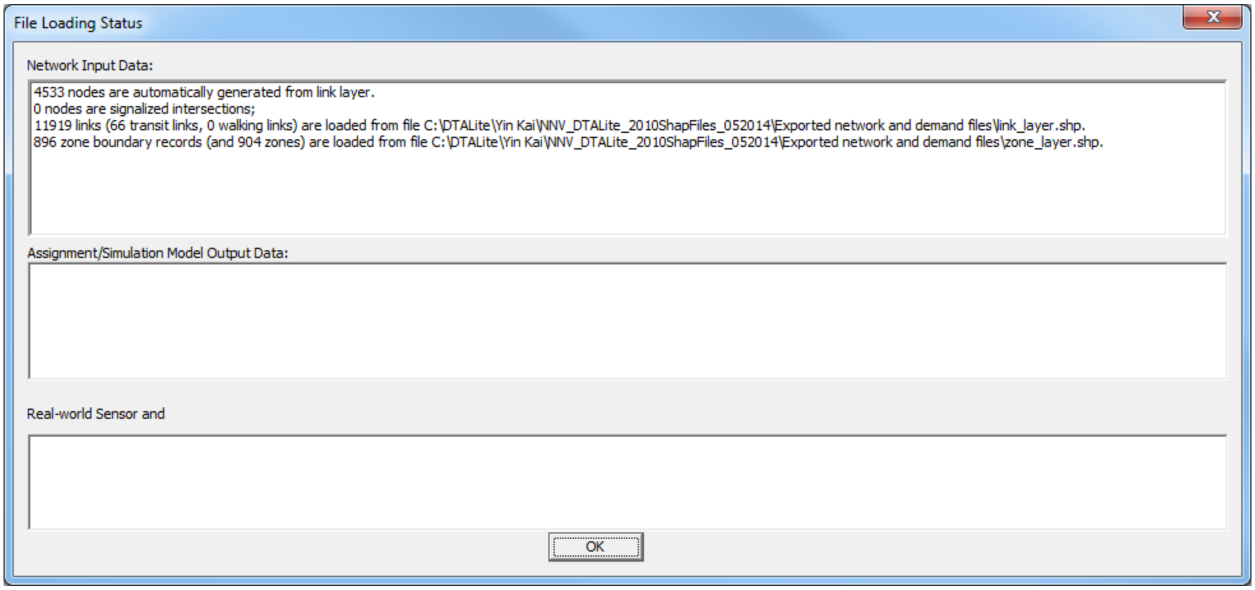


Figure 12. NeXTA File Loading Status for Reno-Sparks Network

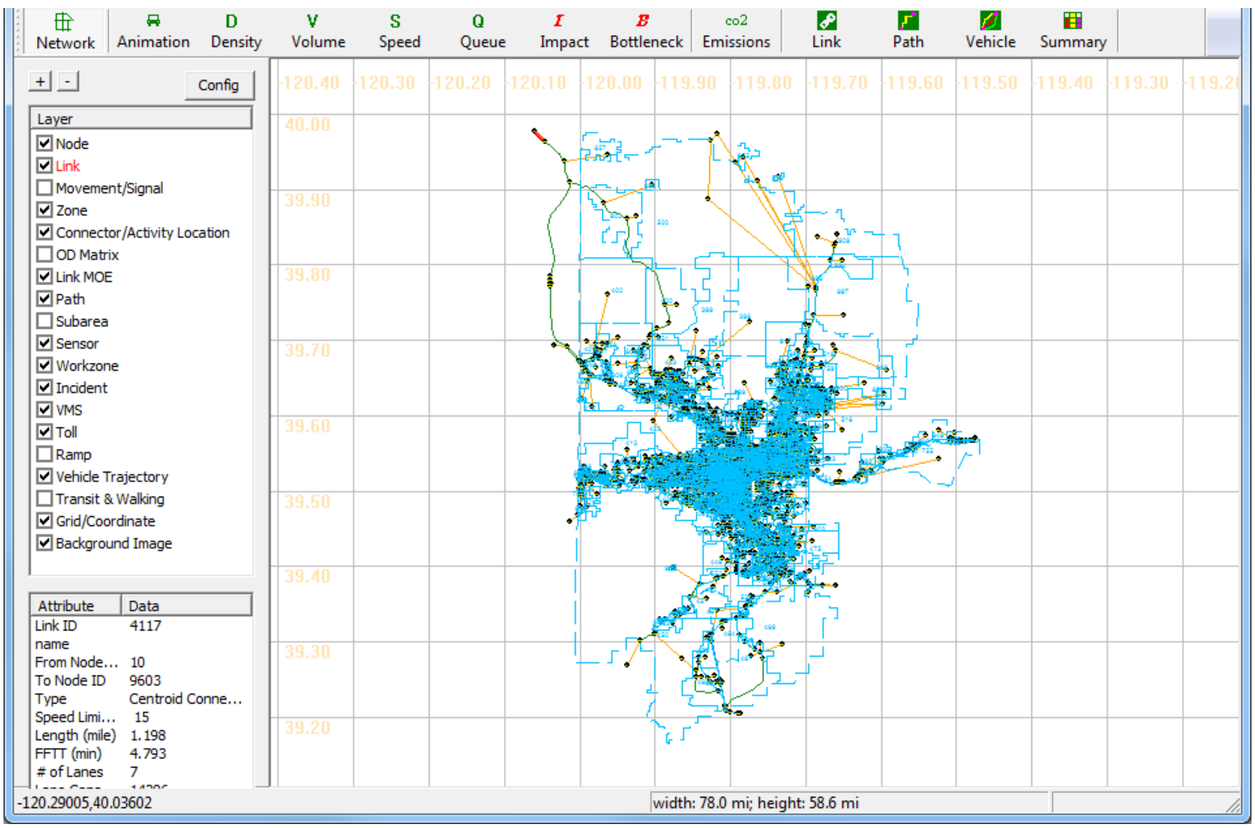


Figure 13. Reno-Sparks Network Loaded in NeXTA

4.2.3 Save the New Network as a New Project file

The last step is to create a new destination folder and to save the network as a new network project (File -> Save Project As) in the created folder, and the new network can now be manipulated through NeXTA. It should be noted that if there are multiple OD tables (see next section), one needs to manually add multiple OD demand files to the new project folder.

4.3 Read Demand Data into NeXTA from Regional Travel Demand Model

As described in section 4.1.3, we have multiple OD demand tables. One needs to prepare input_demand_meta_data.csv associated with the demand files.

In the input_demand_meta_data.csv file, one needs to specify the following:

Specify the demand file name (e.g., trips_am(local_bus).csv) and format (e.g., column);

Specify the number of lines in the demand file to be skipped by DTALite (0 for our case);

Indicate whether subtotals are present in the last column (zero for none);

Specify the loading start time and end time for demand file (e.g.: 360 to 540, meaning 6am to 9pm);

Specify the demand types associated with the demand file.

A screenshot of input_demand_meta_data.csv file is provided in Figure 14.

scenario_i	file_seque	file_name	format_ty	number_of_l	loading_m	subtotal_i	demand_t	start_time	end_time	apply_adc	number_c	demand_type_1
0	1	trips_nt(da).csv	column	0	0.545455	0	0	0	360	0	1	1
0	2	trips_nt(sr2).csv	column	0	0.545455	0	0	0	360	0	1	2
0	3	trips_nt(sr3).csv	column	0	0.545455	0	0	0	360	0	1	2
0	4	trips_nt(local_bus).csv	column	0	0.545455	0	0	0	360	0	1	4
0	5	trips_nt(multiUnitTrucks).csv	column	0	0.545455	0	0	0	360	0	1	3
0	6	trips_nt(singleUnitTrucks).csv	column	0	0.545455	0	0	0	360	0	1	3
0	7	trips_am(da).csv	column	0	1	0	0	360	540	0	1	1
0	8	trips_am(sr2).csv	column	0	1	0	0	360	540	0	1	2
0	9	trips_am(sr3).csv	column	0	1	0	0	360	540	0	1	2
0	10	trips_am(local_bus).csv	column	0	1	0	0	360	540	0	1	4
0	11	trips_am(multiUnitTrucks).csv	column	0	1	0	0	360	540	0	1	3
0	12	trips_am(singleUnitTrucks).csv	column	0	1	0	0	360	540	0	1	3
0	13	trips_md(da).csv	column	0	1	0	0	540	960	0	1	1
0	14	trips_md(sr2).csv	column	0	1	0	0	540	960	0	1	2
0	15	trips_md(sr3).csv	column	0	1	0	0	540	960	0	1	2
0	16	trips_md(local_bus).csv	column	0	1	0	0	540	960	0	1	4
0	17	trips_md(multiUnitTrucks).csv	column	0	1	0	0	540	960	0	1	3
0	18	trips_md(singleUnitTrucks).csv	column	0	1	0	0	540	960	0	1	3
0	19	trips_pm(da).csv	column	0	1	0	0	960	1140	0	1	1
0	20	trips_pm(sr2).csv	column	0	1	0	0	960	1140	0	1	2
0	21	trips_pm(sr3).csv	column	0	1	0	0	960	1140	0	1	2
0	22	trips_pm(local_bus).csv	column	0	1	0	0	960	1140	0	1	4
0	23	trips_pm(multiUnitTrucks).csv	column	0	1	0	0	960	1140	0	1	3
0	24	trips_pm(singleUnitTrucks).csv	column	0	1	0	0	960	1140	0	1	3
0	25	trips_nt(da).csv	column	0	0.454545	0	0	1140	1440	0	1	1
0	26	trips_nt(sr2).csv	column	0	0.454545	0	0	1140	1440	0	1	2
0	27	trips_nt(sr3).csv	column	0	0.454545	0	0	1140	1440	0	1	2
0	28	trips_nt(local_bus).csv	column	0	0.454545	0	0	1140	1440	0	1	4
0	29	trips_nt(multiUnitTrucks).csv	column	0	0.454545	0	0	1140	1440	0	1	3
0	30	trips_nt(singleUnitTrucks).csv	column	0	0.454545	0	0	1140	1440	0	1	3

Figure 14. Example of Preparation for Multiple OD Files in input_demand_meta_data.csv

After all network and demand data are imported, the network is ready for running DTA.

4.4 Run Assignment with DTALite to Equilibrium

The dynamic traffic assignment simulation is performed by DTALite which is directly accessed by pressing the Run Simulation button located in the toolbar menu. Simulation settings should be edited in the input_scenario_settings.csv file prior to initiating the assignment engine.

The popup window that appears shows the defined settings, and allows a selection of the traffic flow model, traffic assignment method, the number of iterations, and the demand loading multiplier, as shown in Figure 15. When the selections are made, pressing "Run Simulation" button will start the DTA simulation.

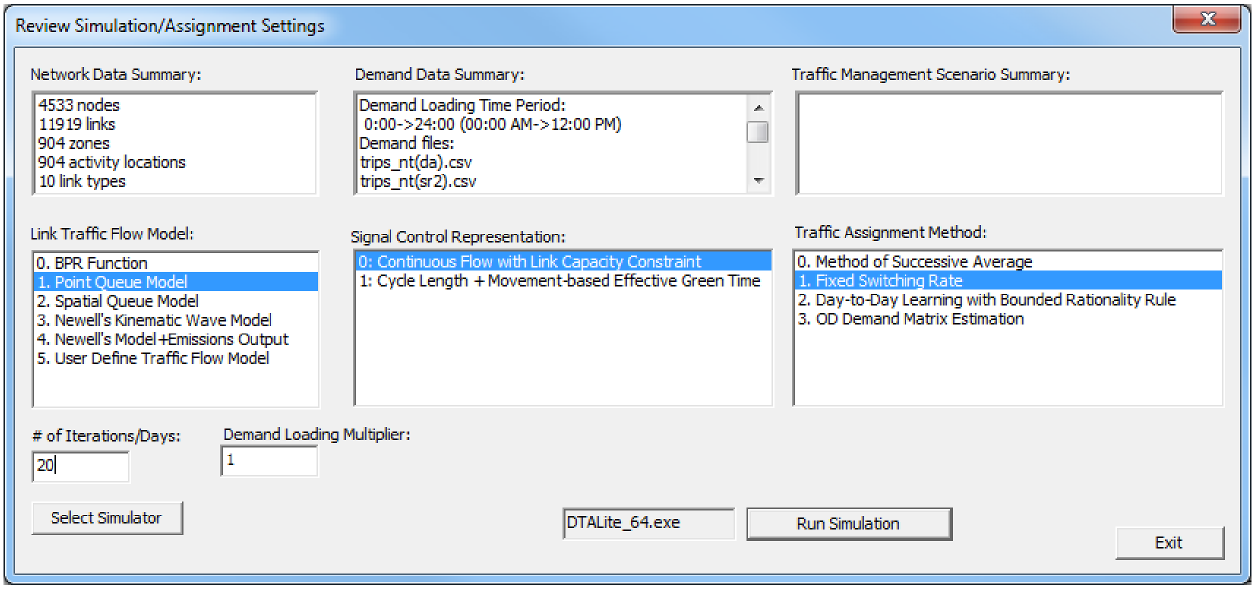


Figure 15. Model Selection for Running Traffic Assignment

At the first run, the point queue model and method of successive average should be used. The number of iterations can be set to 20. DTALite 64-bit version should be used in order to implement the parallel computation to speed up the calculation. For the Reno-Sparks regional network with 20 simulation runs for around 1,200,000 vehicles, DTALite took 1h 43min to complete on an Intel Core I7 3630QM (2.4GHz quad core) with 16GB RAM. It results in an average travel time of 24.90 min and an average trip length of 6.79 miles.

4.5 Change Configurations in input_scenarios_settings.csv File

The initial DTA results might not be consistent with the field observations. Before the OD information can be used reliably to represent the study network conditions, it must be calibrated to observed traffic data. One calibration approach is to adjust the OD matrices. This can be a manual process of adjusting trip table and assigning trips to better fit observed data such as link counts. It can also be an automated step, which is commonly known as Origin Destination Matrix Estimation (ODME).

When massive field observation data are available, one needs to calibrate the DTA model to adapt the available data by modifying the O-D matrices.

Before using ODME to calibrate the whole network, there are parameters needed to be set in input_scenarios_settings.csv file. Table 6 lists the related attributes for ODME and gives corresponding values in this case.

Table 6. Configuration of Related Attributes for ODME in input_scenarios_setting.csv

Field name	Value
number_of_assignment_days	30
traffic_flow_model	1
signal_representation_model	0
traffic_assignment_method	3
ODME_start_iteration	20
ODME_max_percentage_deviation_wrt_hist_demand	30
ODME_step_size	0.05
calibration_data_start_time_in_min	0
calibration_data_end_time_in_min	1440

4.6 Prepare Field (Sensor) Data for Origin Destination Matrix Estimation (ODME)

NeXTA/DTALite's ODME model requires observed field data to be stored in file sensor_count.csv. Therefore this file must be prepared before executing the ODME process. Sensor data uses a flexible format and allows multiple types of observed data related to model validation and calibration in the network. Data types can include link volume, occupancy, speed, and travel time field data for specific locations and time periods.

4.6.1 Check What Kind of Sensor Data Is Available

In our case, for Reno-Sparks network, we can obtain from NDOT the link counts (2010 AADT) of major roads and highways in the network. Therefore we will build the sensor data file based on the AADT data.

4.6.2 Prepare sensor_count.csv File

In this project, we have the link volume count data (AADT) for major road segments in the network. Link volume data should be input in column "**link_count**" in sensor_count.csv. If other types of sensor data are available, they should be input in corresponding columns. For example, average link speed data should be input in column "**avg_speed**", and travel time data should be input in column "**travel_time**".

To map sensors to links (in file input_link.csv), one of the following two methods can be used to specify a link with sensors: (i) use the combination of fields "from_node_id" and "to_node_id", or (ii) field "count_sensor_id", which should be first defined in file input_link.csv. It should be noted that if any values in the column of "count_sensor_id" are not defined in file input_link.csv, warning messages will be issued by DTALite. In this project, we used the second method. Sample values of the fields for sensor data can be seen in Figure 16.

The values of "count_sensor_id" were defined in input_link.csv file using a format of "10002_AB", which is the link id ("10002") joined with a two-letter label ("AB"). For each two-way link in the original TransCAD® network, NeXTA will create two associated links, therefore we should add "_AB" and "_BA" after the link id for each link. For one-way links (e.g. link "10344" in Figure 16), we add "_AB" after each link id.

Additional calculation is needed for the AADT counts data. For each two-way link, the original AADT count is the total traffic volume of two directions. To split the number, we assign ½ of the AADT to each direction. For example, as shown in Figure 16, the AADT of link id "10002" is 730, and we halve the number equal to 365 and assign it to both link "10002_AB" and "10002_BA". For one-way links (e.g. link id "10344") the AADT values remain the same.

count_sensor_id	day_no	unix	start_time_in_min	end_time_in_min	link_count	occupancy	travel_time	avg_speed
10002_AB	1		0	1440	365			
10002_BA	1		0	1440	365			
10279_AB	1		0	1440	16000			
10285_AB	1		0	1440	2000			
10286_AB	1		0	1440	2300			
10289_AB	1		0	1440	7800			
10291_AB	1		0	1440	71500			
10296_AB	1		0	1440	1350			
10296_BA	1		0	1440	1350			
10339_AB	1		0	1440	1500			
10339_BA	1		0	1440	1500			
10344_AB	1		0	1440	3500			
10346_AB	1		0	1440	2900			
10348_AB	1		0	1440	7500			
10348_BA	1		0	1440	7500			
10350_AB	1		0	1440	2600			
10350_BA	1		0	1440	2600			
10397_AB	1		0	1440	12000			
10397_BA	1		0	1440	12000			
10443_AB	1		0	1440	20000			
10485_AB	1		0	1440	750			
10485_BA	1		0	1440	750			
10501_AB	1		0	1440	1200			
10501_BA	1		0	1440	1200			
10526_AB	1		0	1440	2500			
10526_BA	1		0	1440	2500			
10550_AB	1		0	1440	9000			
10550_BA	1		0	1440	9000			
10553_AB	1		0	1440	370			
10555_AB	1		0	1440	4700			
10559_AB	1		0	1440	6100			
10561_AB	1		0	1440	4750			
10561_BA	1		0	1440	4750			
10576_AB	1		0	1440	7500			
10576_BA	1		0	1440	7500			
10578_AB	1		0	1440	6000			
10578_BA	1		0	1440	6000			

Figure 16. Prepare sensor_count.csv file

4.6.3 Modify "count_sensor_id" in the input_link.csv File

Accordingly, in input_link.csv file, identical values of "count_sensor_id" should be defined as in sensor_count.csv file. See Figure 17.

B	C	D	E	F	G	H
link_id	link_key	speed_se	count_sensor_id	from_nod	to_node_i	link_
11687	11687_AB		11687_AB	13712	12318	Loca
11687	11687_BA		11687_BA	12318	13712	Loca
2	2_AB		2_AB	2	9002	Cent
4	4_AB		4_AB	4	10055	Cent
4	4_BA		4_BA	10055	4	Cent
6741	6741_AB		6741_AB	2811	11605	Minc
6741	6741_BA		6741_BA	11605	2811	Minc
11026	11026_AB		11026_AB	13735	8411	Minc
11026	11026_BA		11026_BA	8411	13735	Minc
10446	10446_AB		10446_AB	2313	13186	Loca
10446	10446_BA		10446_BA	13186	2313	Loca

Figure 17. Change input_link.csv file

4.6.4 Filter Unreasonable or Bad Sensor Data

Due to possible data incorrectness or possible inconsistency between the network profile and the sensor data, besides the process of input sensor data into the configuration files, there is a necessity of filtering "bad" sensor data. It requires engineering judgment to determine which data are unreasonable or incorrect so as to be ruled out.

In our case, we find there are two unreasonable data records which might be caused by incorrect mapping between the link and the count station. The following example demonstrates our process of data filtering. Table **7** shows a link record in the network. We can see the link (with the link ID of 4081) has a direction code of 1, meaning it's a two-way road, and its associated NDOT count station ID (field "NDOT-CNT1") is 310629. In Table **8** we can see that the corresponding count station with the ID of 310629 has an AADT of 143000 in year 2010. It's evident that this number is beyond a reasonable range for a freeway ramp. The reason for having a data record like this is unclear but we suspect it could be caused by incorrect mapping of count station to the sample link. Before running ODME to calibrate the DTA model, this data record and another similar record is removed from sensor data.

Table 7. A Link Record in the Network

ID	STREETNAME	NDOT_CNT1	DIR
4081	NB 580 Off @ Glendale	310629	1

Table 8. AADT Record with Count Station ID of 310629

STATION_NU	TRINA_STAN	ROUTE	LOCATION	AADT10
0310629	31-0629	IR580	btwn the Mill St Intch & Glendale Av Intch	143000

4.6.5 Result of Sensor Data Configuration

After the above configurations, sensors are associated with links. Figure 18 shows the locations of sensors.

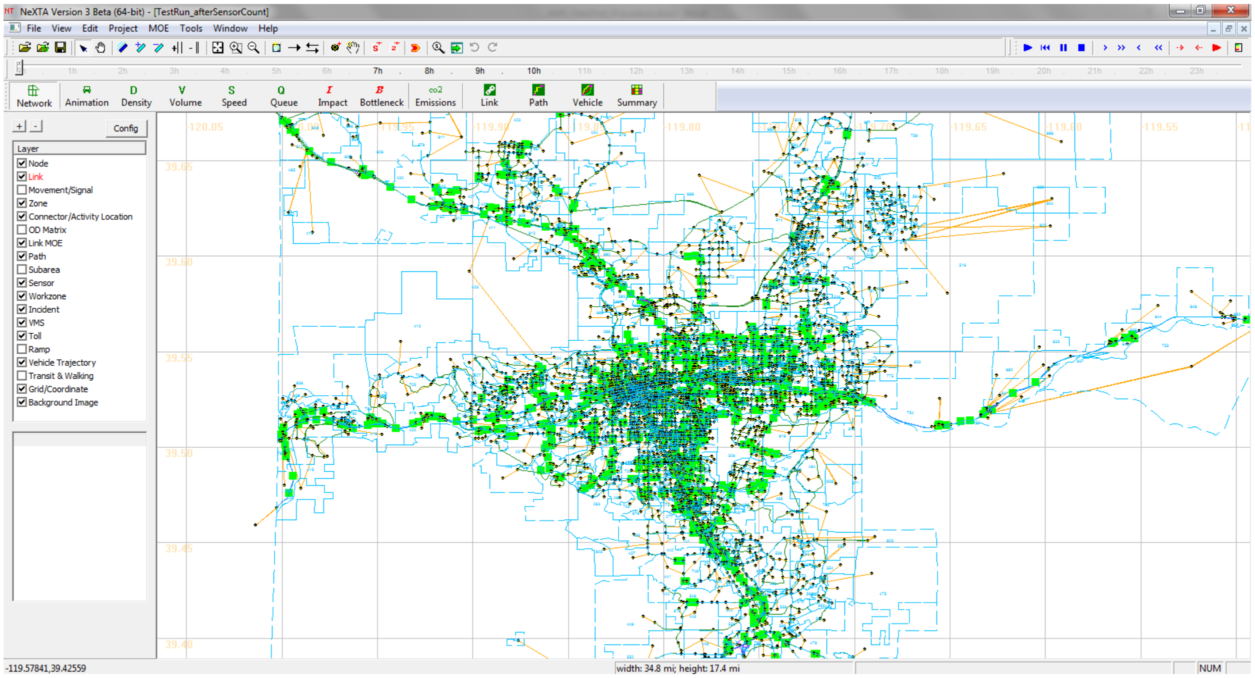


Figure 18. The Green Spots Denote the Links with Sensor Data

4.7 Run ODME Using Field Data for Calibration of the Whole Network

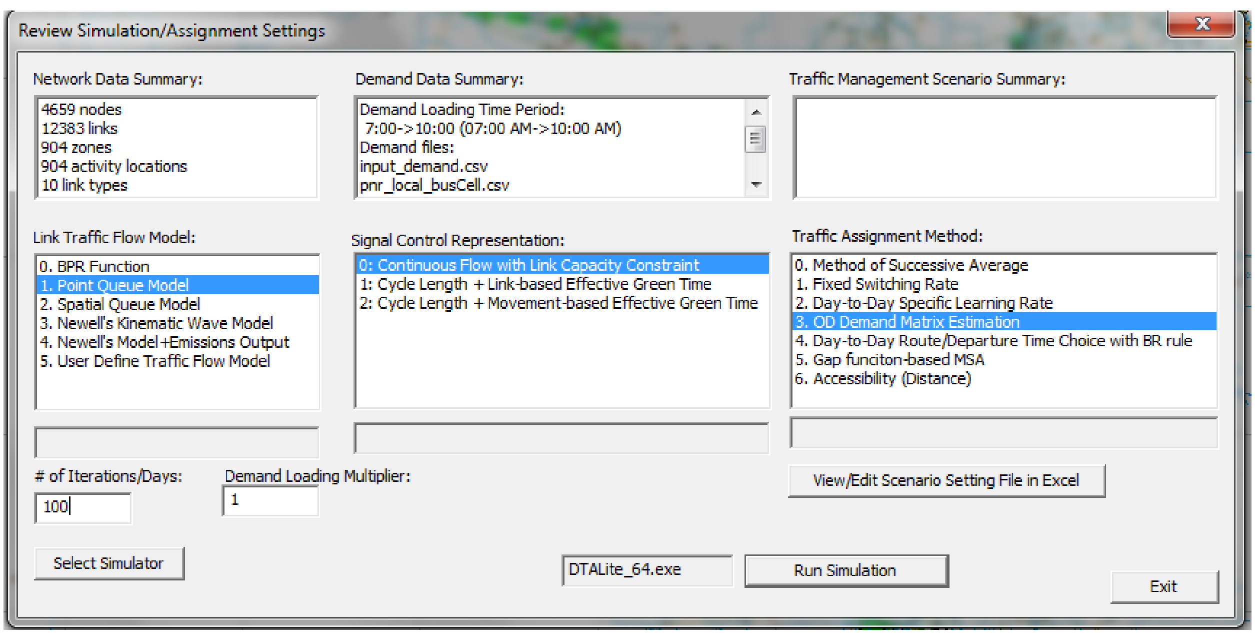


Figure 19. Perform ODME (Note that number of iterations need to be changed to 100)

After ensuring all sensor data are prepared correctly, we now can run DTALite directly. Since Reno-Sparks is a relatively large traffic network, we used 64-bit DTALite which can make use of more than 2GB RAM at once.

According to the previous results, we need to change the number of iterations to 100. Figure 19 shows the setting window for performing ODME.

4.7.1 Check output_summary.csv File

Though checking output_summary.csv file, we can understand the process of ODME using DTALite. For the first 20 iterations, a standard dynamic user equilibrium method, MAS (Method of Successive Average) is used. We can see the UE gap dramatically decreases and finally reaches a relatively small UE gap. In the following 80 iterations, by checking the values of R-squared from the iterative adjustment process, we can see an increasing pattern toward a reasonable statistics.

Figure 20 and Figure 21 show the UE gap and R-squared values during iterations.

Iteratior	CPU Runni	# of ager	Avg Trave	Avg Trip	Avg Waiti	Avg Trip	Avg Speec	% conside	% switche	% complet	network	Avg UE gap (min)
1	0:06:15	1196235	35.9469	21.5265	-14.4205	2.49759	11.3056	100	100	101.542	1440	
2	0:11:28	1196235	25.0766	10.6807	-14.3959	1.23102	16.2174	50.0009	13.677	101.698	1440	14.5773
3	0:16:35	1196235	24.8242	10.4284	-14.3957	1.20343	16.3861	33.335	6.30306	101.698	1440	2.64153
4	0:21:41	1196235	24.8203	10.4249	-14.3954	1.20393	16.3874	25.0015	3.83124	101.698	1440	2.03383
5	0:26:47	1196235	24.796	10.4003	-14.3957	1.20156	16.4001	20.0014	2.79725	101.698	1440	1.80915
6	0:31:59	1196235	24.776	10.3808	-14.3953	1.19978	16.4118	16.6687	2.12231	101.698	1440	1.61735
7	0:37:06	1196235	24.774	10.3786	-14.3954	1.19985	16.4113	14.287	1.69956	101.698	1440	1.54145
8	0:42:15	1196235	24.7661	10.3706	-14.3956	1.19915	16.4147	12.501	1.408	101.698	1440	1.44025
9	0:47:22	1196235	24.7667	10.3712	-14.3955	1.19943	16.4134	11.1122	1.21507	101.698	1440	1.39206
10	0:52:32	1196235	24.7655	10.37	-14.3954	1.19943	16.4133	10.0011	1.0584	101.698	1440	1.35295
11	0:57:41	1196235	24.7601	10.3646	-14.3955	1.19889	16.416	9.09135	0.930992	101.698	1440	1.33356
12	1:02:50	1196235	24.7615	10.3661	-14.3954	1.1992	16.4145	8.33429	0.829886	101.698	1440	1.24957
13	1:08:00	1196235	24.7605	10.3652	-14.3954	1.19918	16.4145	7.69404	0.750728	101.698	1440	1.22854
14	1:13:10	1196235	24.7586	10.3632	-14.3954	1.19902	16.4152	7.14396	0.684229	101.698	1440	1.23783
15	1:18:19	1196235	24.7592	10.3638	-14.3954	1.19917	16.4144	6.6677	0.62521	101.698	1440	1.17449
16	1:23:29	1196235	24.7584	10.3625	-14.3959	1.19908	16.4146	6.25169	0.581726	101.698	1440	1.16564
17	1:28:41	1196235	24.7565	10.3613	-14.3953	1.19898	16.4153	5.88351	0.540462	101.698	1440	1.20587
18	1:33:51	1196235	24.7566	10.3613	-14.3953	1.19903	16.415	5.55702	0.512761	101.698	1440	1.12547
19	1:39:02	1196235	24.7567	10.3614	-14.3953	1.19908	16.4147	5.2643	0.461468	101.698	1440	1.1182
20	1:44:13	1196235	24.7552	10.3599	-14.3953	1.19894	16.4155	5.00127	0.440918	101.698	1440	1.14848

Figure 20. UE Gap during Iterations prior to ODME

Iteration #	CPU Runn	# of agent	Avg Trave	Avg Trip T	Avg Waiti	Avg Trip T	Avg Speec	% c	% s	% cc	netwc	Avg UE ga	Rel	ODM	ODME: Ab	ODME: %	ODME: slc	ODME: r_squared
21	1:44:07	1194346	9.79189	9.82196	0.030073	1.12303	41.6152	0	0	100	1484	0.092879	0	1120	56.295	47.7041	0.936553	0.894789
22	1:45:13	1191436	9.77429	9.80453	0.030243	1.12181	41.669	0	0	100	1487	0.013748	0	1120	55.8999	47.5038	0.93606	0.896562
23	1:46:20	1188975	9.75815	9.78826	0.03011	1.1206	41.7206	0	0	100	1487	0.013151	0	1120	55.5096	47.3012	0.936171	0.898276
24	1:47:26	1186454	9.74237	9.77251	0.030148	1.1196	41.7643	0	0	100	1489	0.012502	0	1120	55.1348	47.1195	0.9361	0.899885
25	1:48:32	1184406	9.74402	9.77399	0.029976	1.12019	41.7499	0	0	100	1485	0.011849	0	1120	54.8126	46.9699	0.936778	0.901448
56	2:21:45	1149026	11.3509	11.3809	0.030034	1.30397	36.064	0	0	100	1488	0.031988	0	1120	49.2438	44.3304	0.963369	0.926736
57	2:22:49	1147563	11.3712	11.4016	0.030431	1.3066	35.9937	0	0	100	1484	0.033586	0	1120	49.102	44.2518	0.962144	0.92718
58	2:23:53	1147200	11.501	11.5314	0.030378	1.32114	35.6035	0	0	100	1486	0.033773	0	1120	49.0232	44.2228	0.963824	0.927592
59	2:24:58	1145670	11.518	11.548	0.03006	1.32335	35.5438	0	0	100	1491	0.035713	0	1120	48.9001	44.1428	0.962364	0.928067
60	2:26:02	1144943	11.5776	11.6081	0.030548	1.33008	35.3703	0	0	100	1488	0.035655	0	1120	48.798	44.0984	0.962612	0.928476
91	2:59:11	1126401	12.7578	12.788	0.03021	1.46112	32.2548	0	0	100	1484	0.039376	0	1120	46.156	42.8241	0.964352	0.938038
92	3:00:14	1125668	12.7506	12.7808	0.03013	1.4605	32.267	0	0	100	1488	0.038724	0	1120	46.0924	42.7825	0.963976	0.938279
93	3:01:18	1125569	12.7926	12.8228	0.030211	1.46475	32.1763	0	0	100	1489	0.038386	0	1120	46.0181	42.7563	0.964806	0.93847
94	3:02:22	1124944	12.8184	12.8486	0.030198	1.46761	32.1147	0	0	100	1486	0.038406	0	1120	45.9586	42.7215	0.964033	0.938784
95	3:03:26	1124908	12.8794	12.9097	0.030294	1.47439	31.9695	0	0	100	1487	0.037658	0	1120	45.8802	42.6856	0.964813	0.938991
96	3:04:30	1125116	12.9399	12.9702	0.030314	1.48058	31.8399	0	0	100	1490	0.038085	0	1120	45.8135	42.6661	0.966198	0.939207
97	3:05:33	1124276	12.8838	12.9139	0.030094	1.47415	31.9787	0	0	100	1485	0.038609	0	1120	45.7533	42.6327	0.9648	0.939523
98	3:06:36	1125264	13.0396	13.0701	0.030503	1.49112	31.6206	0	0	100	1483	0.038254	0	1120	45.6762	42.6192	0.967769	0.939759
99	3:07:40	1124313	12.9604	12.9906	0.030239	1.4826	31.7978	0	0	100	1486	0.038927	0	1120	45.6175	42.5737	0.965354	0.939918
100	3:08:44	1124671	13.0407	13.071	0.030314	1.49161	31.6072	0	0	100	1486	0.035969	0	1120	45.5541	42.5362	0.966811	0.940117

Figure 21. R_squared Values during Iterations with ODME

4.7.2 Check Deviations between Starting and Final Dynamic OD Demand Matrix in File output_ODME_table.csv

This file is used to compare the final ODME result and the baseline OD demand table. Table **9** lists part of the results. Column "origin_zone" and column "destination_zone" define the origin and destination. Column "time_interval" means the travel time from origin to destination at different time intervals. Column "hist_demand_value" means the target demand value or historical demand value, and Column "updated _demand_value" is the estimated demand value. The last two columns are used to analyze the difference between two types of demand.

Table 9. Part of the results for Reno-Sparks Network

origin_ zone	destination_ zone	time_ interval	hist_demand_ value	updated_ demand_value	difference	percentage_ difference
3	7	0	13	13	0	0
3	7	1	16	16	0	0
3	7	2	14	14	0	0
3	7	3	16	16	0	0
3	7	4	16	16.95	0.95	5.9
3	7	5	14	14	0	0
3	7	6	16	15.05	-0.95	-5.9
3	7	7	13	13	0	0
3	7	8	16	16	0	0
3	7	9	16	16	0	0
3	7	10	14	14	0	0

4.7.3 Check output_ODME_log.csv File

After obtaining the final OD matrix, simulated counts can be generated on the basis of estimated OD matrix. In this file, it shows relevant information about simulated counts and observed counts and gives some simple analysis.

4.7.4 Check Observed vs. Simulated Link Volume Plot in NeXTA

To use visualization features available from NeXTA, we can view the validation summary plot, so as to compare the simulated and observed counts. By clicking menu "Tools"->"Sensor

Tools"->" View Validation Summary Plot", we can get the plot for the two types of counts.

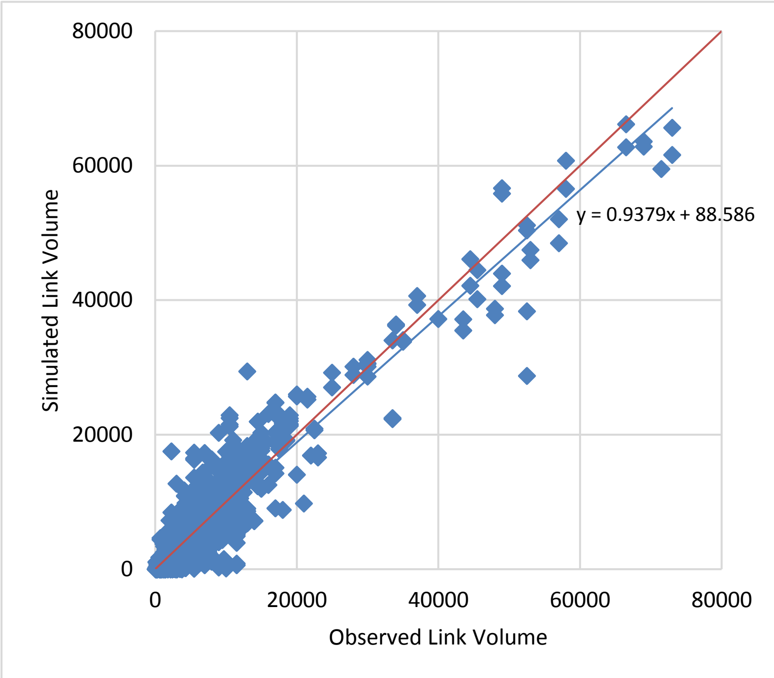
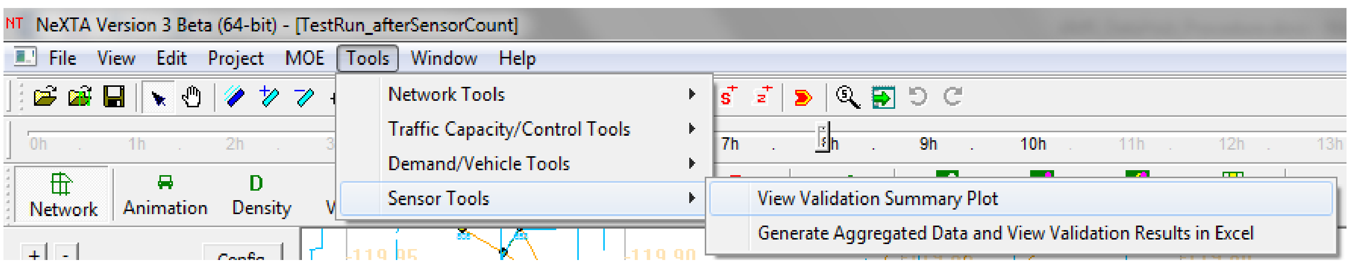


Figure 22 shows the process.



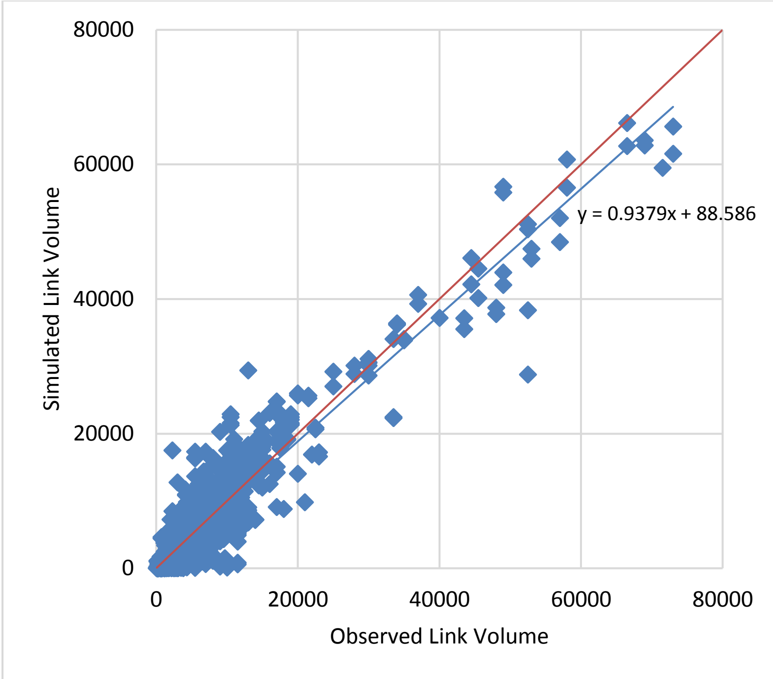


Figure 22. Use Sensor Tools to Validate the Results against Count Data

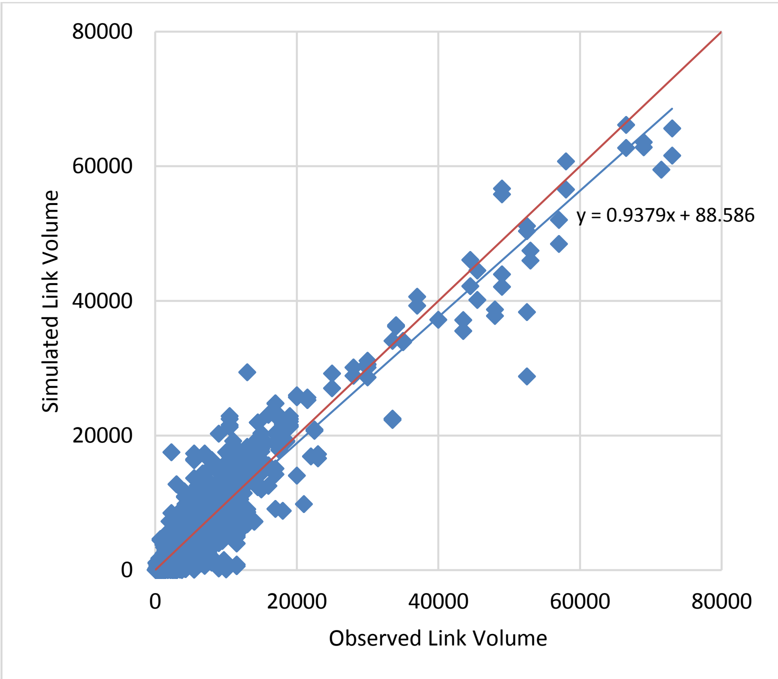


Figure 23 and Figure 24 show the plots before and after performing ODME, respectively. We can see from the plots that compared to the initial DTA model, the Reno-Sparks DTA model after ODME is improved with a better matched link volume distribution.

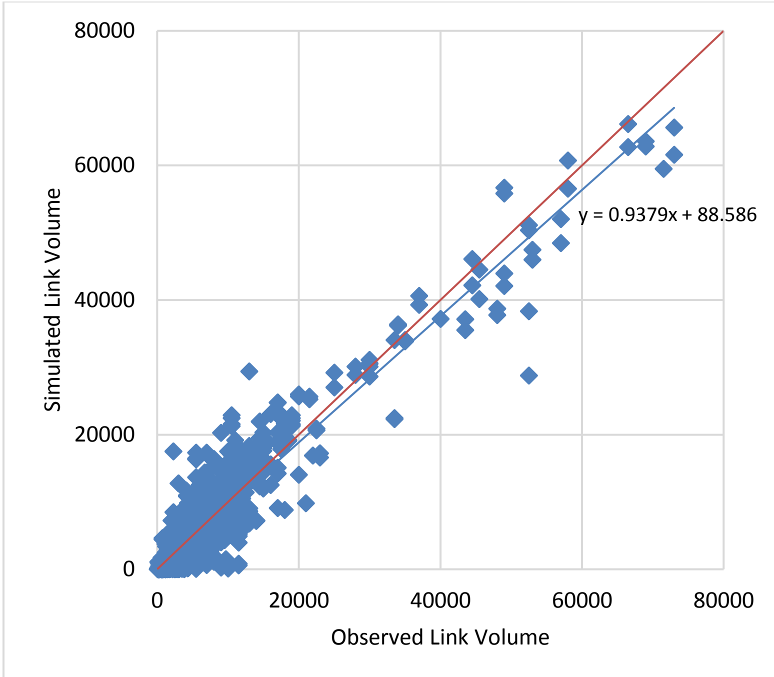


Figure 23. Plot of Simulated and Observed Link Volume (Prior to ODME)

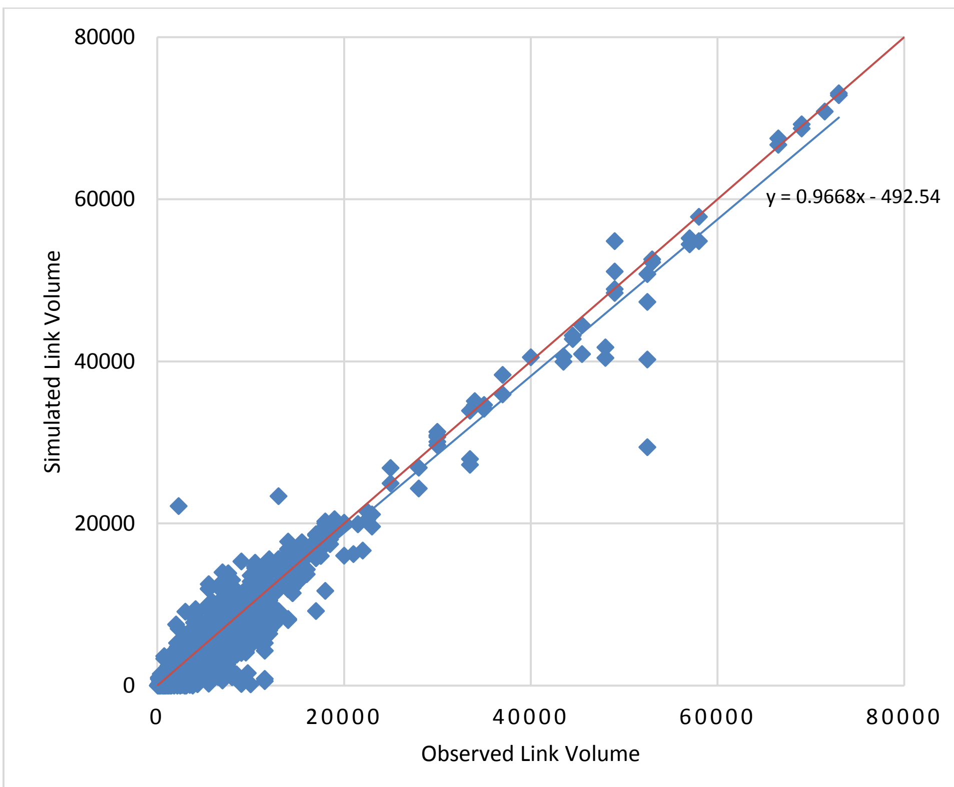


Figure 24. Plot of Simulated and Observed Link Volume (after ODME)

4.8 Further Advancement to Procedures to Further Calibrate the Model

As described in above sections, using link volume data to calibrate the initial DTA model can obtain an improved model to better match the simulated link volumes to observed link volumes. However, due to the lack of detailed field data and limit of project time, the calibration process performed in this project is limited. More calibration processes are not conducted but are highly recommended in order to produce a better-calibrated DTA model. Several methods can be used to continue to advance the research and to achieve a better-calibrated DTA model.

4.8.1 Using Detailed (Time-dependent) Link Volume Data for Network Calibration

Sections 4.5 through 4.7 introduced the network calibration procedure by using AADT link counts. We did not distribute AADT counts over time of day, nor did we obtain time-dependent (e.g. hourly) link volumes. Further calibration can be performed if hourly link volumes, peak hour link volumes, or distribution of link volume over time is given.

Steps are similar as described in above mentioned sections. Sensor data should be prepared and carefully filtered to ensure the data accuracy. File sensor_count.csv should be updated accordingly with regards to the time-dependent link volume data.

4.8.2 Using Link Speed data for Network Calibration

NeXTA/DTALite can use various types of field data to calibrate the network. Besides link volume, other observed data can also be of use. Link speed data is expected to be one of the easy-accessed data at NDOT. Once accurate link speed data is obtained, they can be input into the sensor_count.csv file. Then NeXTA/DTALite can utilize them to conduct model calibration and compare the results with existent model.

Steps are also similar as documented in Sections 4.5 through 4.7. File sensor_count.csv should be prepared accordingly.

4.8.3 Using Micro-Simulation for Subarea Calibration

Micro-simulation tools can be used for subarea calibration to optimize signal timing. This includes conducting several subarea cuts and exporting the subareas into micro-simulation. Traffic signals should be added into the defined subarea network and then the network can be exported to Synchro or VISSIM for signal timing optimization. The procedure should include the steps listed below.

Step 1: Cut a subarea within the larger model for more detailed analysis

Step 2: Run ODME using field data for calibration of the subarea network

Step 3: Add traffic signals, change number of left-turn lanes, and run QEM

Step 4: Export to Synchro/VISSIM for signal optimization/microscopic analysis

Step 5: Test and analyze model characteristics for developing and incorporating signal timing plans into mesoscopic models to improve the accuracy of travel time estimation and assignment.

5 SUMMARY AND CONCLUSIONS

5.1 Project Achievements

In general the research objectives were attained. The DTA model development was completed for the study network of Reno-Sparks area. It successfully demonstrated the conversion from an established TransCAD regional travel demand model into NeXTA/DTALite for mesoscopic analysis.

Basic model calibration and validation against link volume data (AADTs) was successfully conducted and a reasonably improved result has been achieved. It demonstrated the capability of DTALite/NeXTA software package to better match link volume to observed data by adjusting OD matrices.

Although the calibration process improved the initial DTA model to a certain extent, it was considered a limited one because the field data we obtained was not sufficient enough to perform more calibration methods and hence produce a better-calibrated model. It's highly recommended to conduct more calibration processes given that a larger scale of field data is available or can be collected. More details will be provided in Section *Data Requirements for Model Calibration.*

5.2 Capabilities and Benefits of DTA

Given the network characteristics and time-dependent travel demand data—which are typically produced in a TransCAD travel forecasting model—DTA models can be used to estimate dynamic traffic flow pattern over the vehicular network. That is, DTA models load individual vehicles onto the network and assign them on their routes to achieve system-wide objectives.

DTA models provide an easy-accessed graphical user interface (GUI) to display simulation process and statistical results. The assigned vehicle routes can be viewed in the form of (either minute-by-minute or second-by-second) animation. In addition, DTA models provide detailed system-level and link-level outputs that describe time-dependent network performance, and the GUI can these network characteristics and statistics graphically.

The capabilities and benefits of using DTA to analyze traffic network can be concluded as follows:

- DTA provides a mesoscopic traffic analysis tool, providing a connection between regional travel demand forecasting and micro-simulation models.

  Travel demand forecasting models such as TransCAD typically provide long-term travel demand forecasting for large-scale networks and micro-simulation tools such as VISSIM and SimTraffic typically focus on animation of individual vehicle movements on small networks. DTA is a connection between these two types of tools, which can both handle the network scale as of TransCAD and display animations of individual vehicles running in the network as similar to VISSIM.

It is one step further from the planning level of travel forecasting towards the operating detail of micro-simulation, i.e., DTA analyzes large networks as a travel planning tool and provides time-varying traffic network performance (e.g., queue formation, bottleneck identification) but not as much detailed as micro-simulation models.

- Comparing with micro-simulation models which normally represent known traffic flow patterns, DTA can both represent current traffic performance and evaluate near-term traffic flow impacts from network changes.

  Micro-simulation tools are typically designed for traffic performance analysis of current network of road facilities from an operational perspective. Their primary advantage is recreating real life scenarios and providing visualized representation of traffic performance.

  DTA models can be used for both operational and planning perspectives. It is particularly useful to model a regional level network to forecast traffic flow pattern changes and operational impacts due to incidents such as work zone, special events, and accidents.

- DTALite/NeXTA features built-in demand adjustment tools in ODME for model calibration.

  As demonstrated in Chapter 4, DTALite/NeXTA features ODME as one of the calibration methods to better match simulated link volumes to observed field data. The demand adjustment tools in ODME are easy to use and the capabilities of changing start times and using alternative route choices for traffic assignment are particularly beneficial in model calibration. This represents the potential for time savings, especially for large networks.

5.3 When to Apply DTA models

DTA is a relatively new tool to analyze large-scale route choice alternatives, and can also be a useful tool in the evaluation of a wide variety of transportation conditions. Appropriate applications of DTA models include, but are not limited to:

- Visual animation of vehicles on a large scale network.

  DTA tools can provide a coarse animation of individual vehicles running on the links of a large-scale network over the simulation period. However the level of simulation is not as detailed as micro-simulation tools. For example, DTA cannot model lane change or intersection operations.

- Visual display of system performance details of a large scale network.

  DTA provides a GUI to display system-level and link-level statistical outputs that describe time-dependent network performance, such as link volume, density, link speed, queue formation, and bottleneck identification. It's an efficient tool to present traffic planners and operators the visualization of these network performance measurements.

- Work zone analysis.

  DTA models can be used for analyzing work zone impact on a given network. By simulating vehicle routing choices, it can determine where cars would reroute during short-term construction area or long-term road closures for construction.

- Near-term planning project analysis.

  DTA models can be used to determine what impact it will have on an entire network or a specified area if a near-term planning project is likely to induce a travel pattern change in time or space among different facilities. Such projects may include

  (a) significant roadway configuration changes (e.g. change streets from one-way to two-way or vice versa),
  (b) freeway expansions or road diet,
  (c) lane use changes such as adding or converting HOV–HOT lanes,
  (d) travel demand management strategies such as peak spreading or congestion pricing,
  (e) special event,
  (f) incident management response scenarios (e.g., evacuations), and
  (g) bottleneck removal studies.

5.4 Requirements for DTA Development and Applications

To build and calibrate a DTA model to closely represent real traffic conditions, there are several requirements that must be met, including data requirement and modeling efforts.

5.4.1 Data Requirements for Network Development

For network development, basic data requirements include: geometric data, traffic control data, traffic demand, OD demand data and transit demand.

For DTA modeling, estimating the demand is of critical importance. This includes estimating not only the origin and destination patterns, but also the temporal distribution of travel demand. Building a DTA model without this type of information is very difficult. Preferably the travel demand data is desired to be divided into very short time intervals such as a 5 or 15 minutes. Typically a regional travel demand model (e.g. TransCAD model) can provide network characteristics as well as OD travel demand data. Ideally the travel demand model should distribute daily demand (24-hour assignment) into peak periods or individual hours.

5.4.2 Data Requirements for Model Calibration

For model calibration, quantified measures of effectiveness that can be observed in the field or produced from other model outputs are required. In our project, the calibration was conducted by using ODME, which required link volumes data. As we were only able to obtain AADTs for freeway and major links, model calibration was limited to a certain extent. The fidelity of a DTA model depends on more than link volumes.

Depending on availability and coverage of observed data sets, model calibration methods vary. In general, the calibration process compares field data to the model outputs, and if the calibration acceptance criteria are satisfied, the model is considered calibrated. Typical types of data for calibration strategies can include:

- Travel times;
- Travel speeds;
- Traffic counts (including temporal peaking, preferably hour-by-hour link volumes);
- Lane utilization;
- Queue information; and
- Transit operations.

However, these types of data are not all required for a single DTA application. When developing a DTA model, modelers should consider the primary area within the network for calibration and what performance measures are most importance, and prepare data collection plans accordingly.

5.4.3 Transportation Modeling Skills

The application of DTA requires skills of existing transportation modeling techniques. Having fundamental knowledge of travel demand modeling and micro/mesoscopic simulation modeling techniques and working knowledge of model calibration and statistical analysis is needed to apply DTA successfully.

5.4.4 Level of Efforts

Based on the choice of DTA software package, network size, data collection needs, and model limits, the level of effort needed in a DTA application can vary significantly. More detailed network profile, travel demand data with shorter time intervals, and more sufficient observed data sets of multiple types and wider coverage are a prerequisite for potential time savings. Otherwise a large amount of time will be spent on data collection rather than model building and calibration.

5.5 Limitations of DTA Applications

Applying DTA methods may require more effort than other static transportation modeling techniques, however; therefore, the need for DTA methods should be considered carefully, taking into account data needs, model building time, and calibration. DTA models are not the universal solution for all types of traffic problems.

5.5.1 Regarding Long-term Planning

DTA can be a good tool for present and near-term network performance analysis. For example, it can easily identify active bottlenecks and queue formation of the study network when analyzing the impact of a short-term planning project. However for long-term planning, DTA tools will not be able to adjust model parameters to produce a well-calibrated model because there are no observed field data to calibrate against. The lack of future travel demand data and corresponding field data makes DTA not a suitable tool for long-term planning.

Instead, travel forecasting models such as TransCAD is a better fit for bottlenecks (including upstream and downstream) estimation studies. While DTA can only identify active bottlenecks, travel demand forecasting models can predict all potential bottleneck locations, which is necessary for long-term planning purposes. .

5.5.2 Regarding Resolution of Travel Demand Data and Data Collection Effort

When detailed input data required for DTA is unavailable, one may have to make many assumptions to build such models. For example, if the travel demand data are provided as an OD matrix describing trips for a day rather than trips in 15-minute intervals, the temporal distribution of travel demand is unclear so that the assigned trips is difficult to replicate real traffic conditions.

The level of precision from DTA models largely depends on data availability. DTA requires a significantly larger amount of data which may not be readily available in most cases. If the additional effort to collect detailed input data offsets the precision in the DTA output data compared to travel forecasting models, it may not be beneficial to apply DTA and not worth the additional modeling effort. Decision makers need to assess the desired level of precision and the available resources and choose if DTA or conventional travel demand models should be used.

5.5.3 Regarding Smaller Area Analysis

Although DTA tools can model vehicle trajectories and display their movements on links, it's limited in the degree of simulation resolution to model more detailed network performance.

For a smaller network or area, if a careful examination of traffic behavior is needed, micro-simulation is an ideal tool to continuously model car movements and include a more detailed description of roadway facilities and multiple traffic modes.

5.5.4 Regarding Pedestrian Simulation

As described in previous sections, DTA is a useful tool to model vehicular network, including traffic and transit. But it cannot simulate pedestrian behaviors. If pedestrian mode is required for the study, microscopic models may be more appropriate.

5.6 Future Research Focuses

The DTA calibration conducted in this project is considered limited due to data availability and time constraints. Future efforts should be directed to the following aspects.

5.6.1 Model Testing with Detailed Signal Timing and Turn Pockets

In the current DTA model, detailed signal timing and turn pockets are not coded. It would be interesting to test how sensitive the DTA results are with regard to adding such detailed information.

5.6.2 Further Model Calibration

Current model calibration was based on AADT link counts. We did not distribute AADT counts over time of day, nor did we obtain time-dependent (e.g. hourly) link volumes. Further calibration can be performed if hourly link volumes, peak hour link volumes, or distribution of link volume over time is given.

Further calibration should utilize link speed data which is easily accessible from NDOT maintained ITS devices. Accurate link speed data can be input into the sensor_count.csv file. NeXTA/DTALite can utilize them to conduct model calibration.

5.6.3 Model Applications through Case Studies

Some case studies should be conducted to demonstrate the applicability of DTA models. Very limited literature was found to document such case studies. In the case of incident conditions, a comparison between DTA generated results and the actual field performance will give transportation agencies some confidence level of the validity of DTA modeling.

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